ENGINEERING NEWS-RECORD

JANUARY 16, 1941

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NNUAL HIGHWAY NUMBER • ***Roads in the Defense Program***

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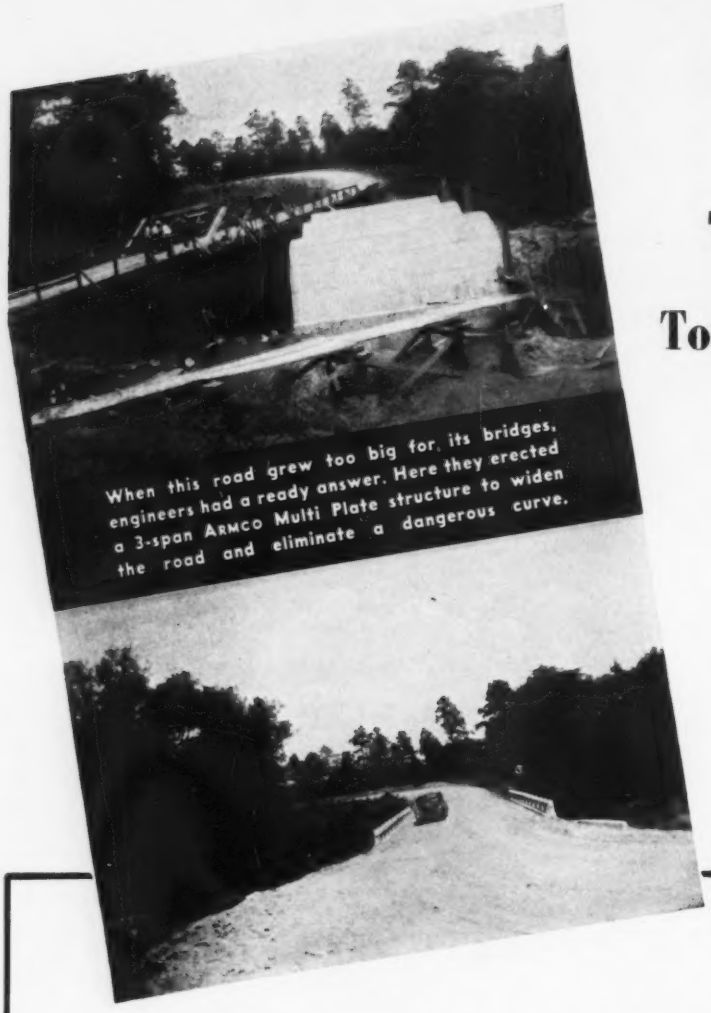

When this road grew too big for its bridges, engineers had a ready answer. Here they erected a 3-span ARMCO Multi Plate structure to widen the road and eliminate a dangerous curve.

The Road That Grew Too Big For Its Bridges!

• When roads must expand, an obsolete bridge is like a tight pair of pants. Yet you can "let out the seams"—eliminate these horse-and-buggy bottlenecks by extending or replacing them with ARMCO Multi Plate structures.

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WALDO G. BOWMAN, *Editor* • ALBERT E. PAXTON, *Manager*

Vol. 126 JANUARY 16, 1941 No. 3

THIS WEEK

• This issue, the Annual Highway Number, is given over in large part to a presentation of the place of roads in the national defense program. Supplementing this is a survey of the work and expenditures of the individual states for roads during 1940 and estimates of expenditures to be made in 1941. To round out the national picture, the statistics of expenditures are grouped into their major classifications.

• Major elements of the road problems that have developed under the defense program are separately treated, and specific operations are described. These articles include the first major camp access road to be built in this country, construction of a major link in the strategic highway network, what is being done at Los Angeles and Seattle to handle traffic at plants working on defense orders, and the experience of four states in handling army maneuvers.

• Outstanding in highway work in 1940 was completion of the Pennsylvania Turnpike. How it is being operated, how the tunnels are lighted, and what provisions are made for safe night driving, are told in this issue.

Cover photo courtesy of U. S. Army Signal Corps.

THINGS TO COME

• The history of Austin Dam and its recent reconstruction illustrates a half century's advance in engineering practice and construction methods applied to foundations in bad rock. The underpinning requirements necessary in its reconstruction will be described in Jan. 30 issue.

• The Pharoah and His Planning Board is a story with a flavor that will tickle the palate of every engineer, and should prove to be a highlight of the forthcoming Jan. 30 issue.

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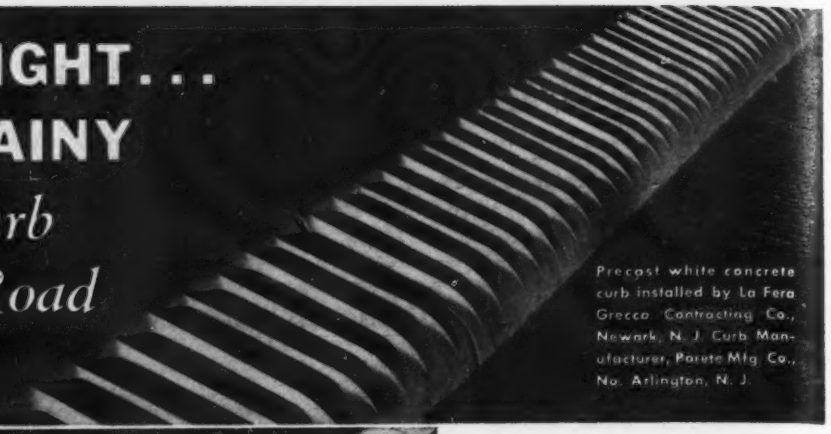
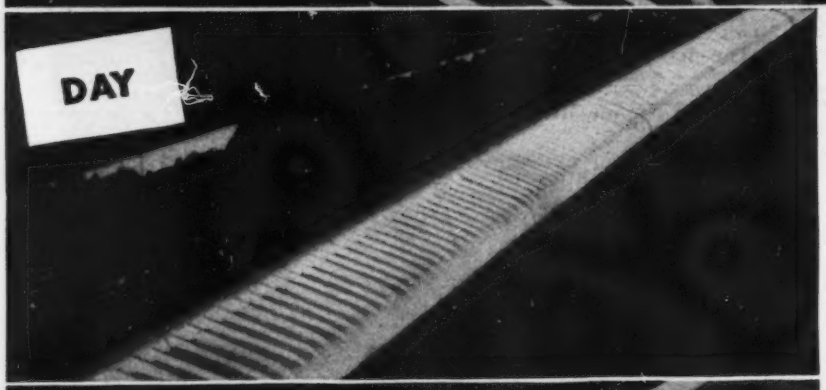
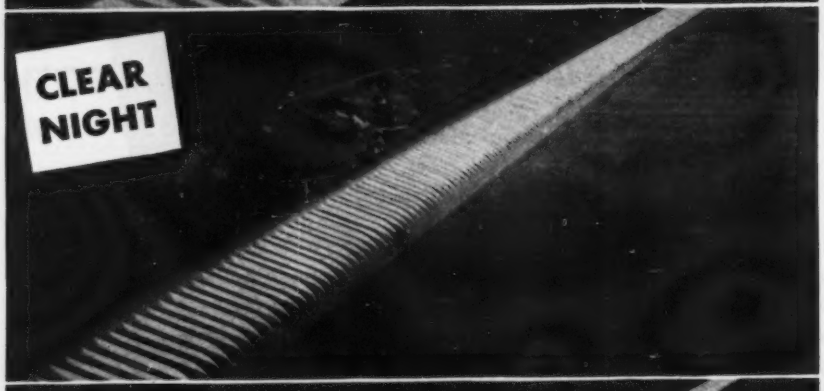
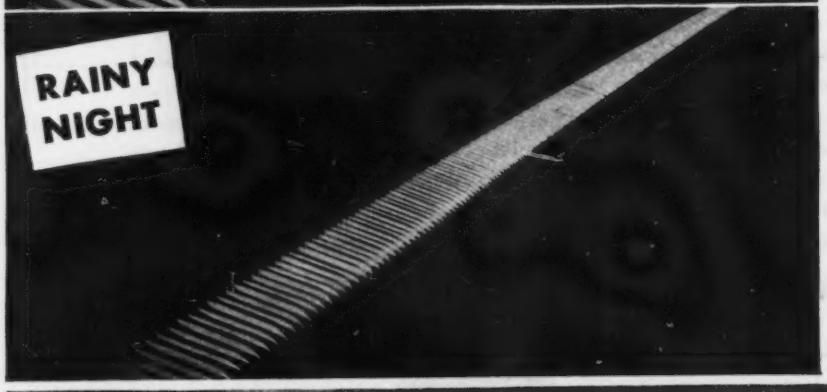
DAY OR NIGHT...
DRY OR RAINY
Reflecting Curb Defines the Road



Precast white concrete curb installed by La Fera Grecco Contracting Co., Newark, N. J. Curb Manufacturer, Parete Mfg. Co., No. Arlington, N. J.







This White Concrete Reflecting Curb increases visibility to an amazing degree. It dominates the road by day, adequately defining the center island, and is even more visible at night. The curb shown is on the approach to Passaic River Bridge, Route 25, Kearny, N. J.

Night falls. It is clear. The road is dry. **Under car headlights only—no other illumination—the curb stands out sharply, defining the road. The sawtooth faces of the curb, which lie approximately perpendicular to the headlight rays, catch and reflect the light back to the driver, and thus make the curb visible.**

On a rainy night **water fills the indentations in the concrete road, causing it to reflect most headlight rays away from the driver. The road is blacked out. But when the road seems to disappear, reflecting curb shows up at its best. Water on the reflecting faces causes them to act more like mirrors—and they direct even more light back to the driver.**

VISIBILITY OF THIS CURB HELPS TO CUT ACCIDENTS. IT IS EASY TO INSTALL, PERMANENT, AND ECONOMICAL.

For complete information, write Universal Atlas Cement Co. (United States Steel Corp. Subsidiary), Chrysler Bldg., N. Y. C. Offices: New York, Chicago, Philadelphia, Boston, Albany, Pittsburgh, Cleveland, Minneapolis, Duluth, St. Louis, Kansas City, Des Moines, Birmingham, Waco.

NR-M-17

WHITE CONCRETE REFLECTING CURB

MADE WITH ATLAS WHITE CEMENT

Labor shortage not yet serious in construction

Shortages in Atlantic States area, where one-third of all defense contracts have been allotted, and in Northwest are in contrast to remainder of country.

Receiving reports of a labor shortage in a few parts of the United States, *Engineering News-Record* has made a nation-wide survey of how the defense program is affecting the supply of labor for the construction industry and of available engineering personnel. This survey reveals that, for the most part, the labor supply is meeting the industry's needs, although in certain areas, principally the Atlantic States, there have been serious local shortages. Some engineering offices are losing men to higher paid jobs on defense work. The situation may best be described by areas.

Conditions in the Atlantic States

Although there are some local shortages of semi-skilled and even unskilled construction workmen, in general the labor supply is meeting the demand in New England. All reports for the city of New York and surrounding area show no shortages of construction men.

With more than one-third of all defense contracts allotted to the Middle Atlantic States area, causing an extremely sharp increase in industrial and construction activity, there is general difficulty in obtaining skilled and semi-skilled construction workers in that area, according to Paul V. McNutt, federal security administrator.

A shortage of engineers and skilled workers, which has already reached rather serious proportions and promises to be even more acute, is reported for the Baltimore territory. There are also some reports that semi-skilled and even common labor are short in some instances. That there is a shortage of carpenters, bricklayers, stone masons, cement finishers, plasters and sheet metal workers was pointed out. Some of the engineering departments in the Baltimore municipal government have been hard hit by the fact that about 50 engineers, inspectors, and other trained employees have already left for better positions or military duty. Many engineers and skilled workers have left the Maryland State Roads Commission with the bridge division being hardest hit.

Scarcity of draftsmen, plumbers and steam-fitters heads the list of construction labor difficulties in the eastern Pennsylvania district. W. H. Herman, personnel director of the Pennsylvania highway department reports that about 140 engineering employees have resigned during recent months to take defense jobs or employment with the allied industries. There is a shortage of draftsmen in the department, he reports, but other classifications are pretty much filled. Completion of the Penn Turnpike has released a large number of good men. Labor union officials at Pittsburgh in fact express disappointment over the small amount of labor that has been absorbed. Ample skilled labor is available for any construction that could possibly be anticipated for the Pittsburgh area.

No extra labor in W. Virginia

Continued activity in the construction field and favorable weather has resulted in practically one hundred percent employment for all types of construction labor in the Charlestown, W. Va. area. Although skilled labor is not plentiful, the supply and demand seems pretty well balanced but with both the state of West Virginia and industry reporting a serious shortage in young civil engineers, draftsmen, technical office work-

(*Continued on page 72*)

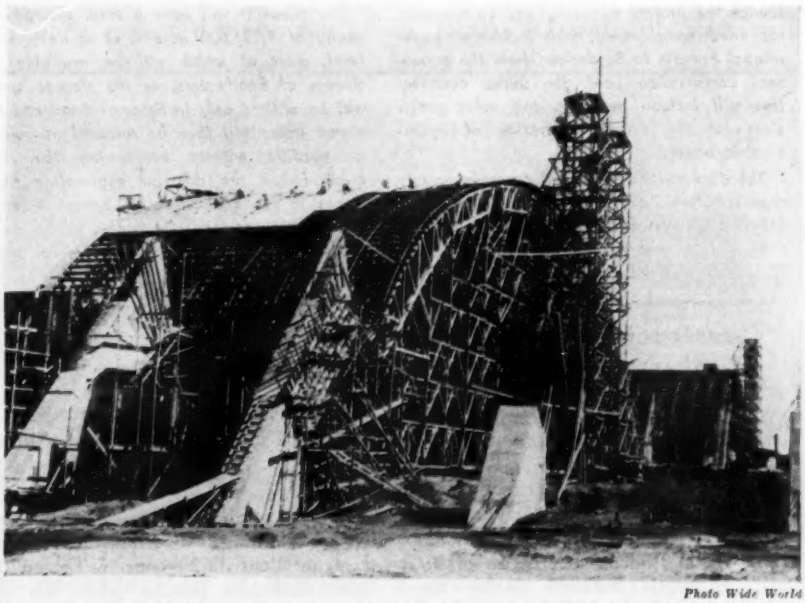
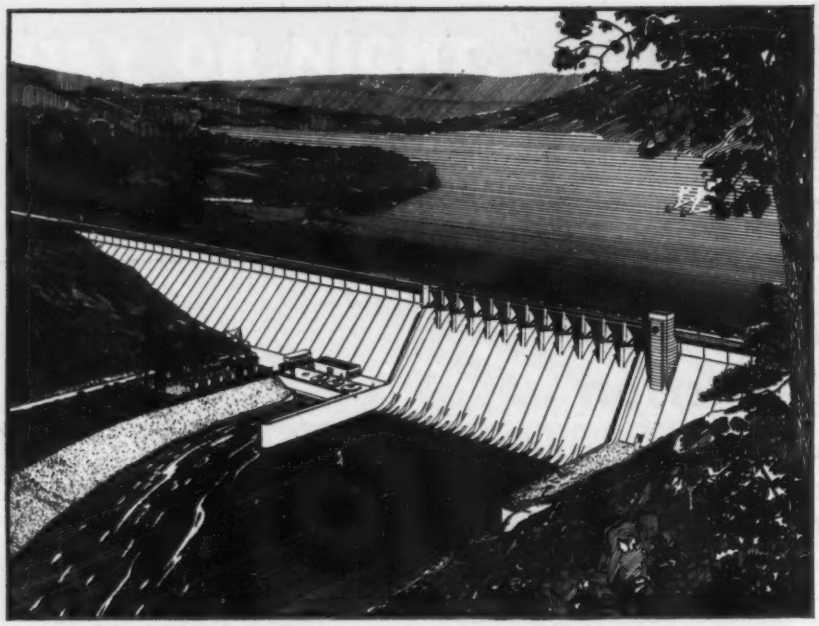


Photo Wide World

Army tries concrete hangars at Borinquen

Most of our airbase hangars are of steel, but at the Army's new field at Borinquen, on the west tip of Puerto Rico, the Army has gone in for reinforced concrete. The two hangars shown under construction here are of thin shell design with supporting arch ribs. Dimensions are not given, but the hangars are known to be large enough to accommodate the biggest bombers. The Navy is also building concrete hangars at San Diego.



Bids for $25,000,000 Norfork Dam to be opened Feb. 20

Bids will be opened Feb. 20 in the office of the U. S. Engineers at Little Rock, Ark. for construction of the Norfork Dam and reservoir project on the North Fork River, about 5 miles northeast of the village of Norfork, Ark. and about 100 miles north of Little Rock. Estimated cost is $25,000,000.

Norfork reservoir will be one unit of a comprehensive reservoir system on the White River and tributaries for flood control in the lower White and Mississippi river valleys. Although the project originally will be operated for flood control only, with incidental recreational benefits to be derived from the permanent conservation pool, the initial construction will include penstocks and other provisions for the future generation of hydroelectric power.

The dam will be a straight concrete gravity type structure 2,624 ft. long with a maximum height of 220 ft. above stream bed. The overflow spillway will have a total length of 568 ft. which will be reduced by piers on the crest to a net clear length of 480 ft. The piers will support a service bridge and the future spillway crest gates. A stilling basin will contain concrete baffles to supplement the stilling action of the pool in dissipating the kinetic energy.

Major items of work include an estimated 850,000 cu.yd. of excavation, 102,000 lin.ft. of core drilling, 1,500,000 cu.yd. of concrete, and 2,700 tons of metal in the form of pipe, slide gates, iron castings, and structural steel.

The reservoir will have a total storage capacity of 1,251,000 acre-ft. at spillway crest level, most of which will be available for storage of floodwaters, as the storage space will be utilized only in times of flood and the stored water will then be released as quickly as possible without overflowing the river banks below the dam or augmenting flood stages in the White River. Except in cases of excessive run-off, the pool will be maintained at a relatively constant level for recreational purposes.

Construction started on Box Butte Dam

After eight months of site preparation, construction work on the $2,560,000 Box Butte irrigation dam, 7 mi. north of Hemingford, Nebr. has been started for the U. S. Bureau of Reclamation. This project will be a rock-faced earth dam, about 4,200 ft. long and 64 ft. high. It will impound Niobrara River flood waters to irrigate 12,000 acres in the Mirage Flats region in cental Sheridan County. When completed, the dam will store 30,000 acre-ft. of water. The reservoir will reach an ultimate length of approximately 5 mi. G. E. Buchanan, district engineer for the WPA project, estimates that 20 months will be required for completion.

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Safety record broken on Tenn. Powder Co. project

A new world's safety record for construction work has been established by E. I. du Pont de Nemours & Co. on the new smokeless powder plant for the Tennessee Powder Co., near Memphis, Tenn. Not a single time-losing injury has occurred during more than three million working hours. The previous record in construction, according to the National Safety Council, was 1,929,478 hours.

Model studies planned for proposed Mackinac span

Every precaution is being taken to perfect and check the design of its proposed suspension bridge over the Straits of Mackinac in Michigan, announces the Mackinac Straits Bridge Authority, not unmindful of the inevitable comparisons that are being made as a result of the collapse of the Tacoma Narrows span.

Slenderness ratio for both width to length and depth of truss will be determined after subjecting models of the bridge to an extensive series of dynamic, as well as static loadings, and gathering such information as can be obtained by the use of a wind tunnel. The preliminary plans and studies of the proposed construction contemplated the use of models to determine the effect of dynamic forces and provided for the cost of these studies. These studies contemplated the use of trusses instead of plate girders as the stiffening members and an open grid floor instead of the usual solid slab on the basis that such a floor has advantages in reducing the uplift from pocketing winds.

Mackinac Bridge will consist of two suspension bridges placed tandem, with a common central anchorage as used on the San Francisco-Oakland Bridge. One of the main spans is 2,950 ft., while the other is 4,600 ft., the longest yet attempted. Designing engineers for the Authority are Modjeski & Masters, New York, N. Y., and Harrisburg, Pa. Estimates made early in 1940 placed the cost of the project at $24,740,000 without interest and financing charges.

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N.Y.C. airport building damaged by settlement

Differential settlement of the pile foundations under the administration building at La Guardia Field, New York City's municipal airport, has resulted in serious cracking of walls, floors and partitions. This news was revealed to the general public through newspaper stories early this week, although the settlement has been common knowledge in engineering circles for several months. It has in fact been under study and observation for nearly a year, first by the WPA, which built the airport, and more recently by the city dock department, which is charged with its operation and maintenance.

The airport is built on a new fill of ashes and rubbish placed on a deep bed of soft silt. Much of the area is reclaimed land from Flushing and Bowery Bays, although the site of the administration building is inside the original shoreline. Fill under the building is of two ages, however, and some of the differential settlement is said to be attributed to this

fact. However, the principal cause is believed to rest in inadequate penetration of the pile supports—closed steel tubes filled with concrete. These piles were driven nearly 90 ft., first through the new fill and then through about 55 ft. of soupy silt into a sand-clay stratum, where they were stopped, apparently for reasons of economy. Below the sand clay is more soft material, and rock or hardpan is not struck until a depth of 105 to 110 ft. is reached. Compression of the soft material below the pile tips could account for the excessive settlement, it is believed.

Settlement, which on such a base was not unexpected, began three or four months after the building was completed. For a time it was quite rapid, but recently it has slowed down to about ¼ in. or less per month. Maximum settlement is 3 in. and maximum differential settlement among the 9 badly affected piers is about 1½ in.

To arrest any further settlement the dock department is now engaged in exposing the footings of 16 of the piers and welding brackets on each side of the columns. Hydraulic jacks will then be installed under each bracket to permit continuous shimming of the footings, thus holding the building in its present position regardless of pier settlement. It is estimated that settlement will cease after about six months when new base plates can be installed and the jacks removed. The cracks in the building can then be cleaned out and patched. Supervision of the work is in the hands of John McKenzie, commissioner of docks, and Joseph A. Meehan.

Central authority established for defense housing program

President creates Division of Defense Housing Coordination with new power delegated to C. F. Palmer as its chief

Centralized authority over the defense housing program was established for the first time this week when the President by executive order created the Division of Defense Housing Coordination and made Housing Coordinator Palmer its chief. Previously, although Palmer was supposed to coordinate housing, he had only advisory powers. Disagreements among the various housing agencies—never much given to agreeing among themselves—or between Palmer and one of the agencies could formerly be settled, in the last analysis, only by appeal to the President. Now Palmer can give orders.

Palmer is responsible only to the President. Creation of the new division is a part of the general tightening of the whole defense set-up in recent weeks, but Palmer is not a part of the Office of Production Management. Rather, his division is parallel to OPM; both are technically branches of a theoretical paper organization created by the President in a reorganization plan last summer and known as the Office of Emergency Management. Palmer's division has authority over all civilian defense housing; press reports that he has something to do with cantonment construction are incorrect. He has power to determine what housing shall be built, in a general way what agencies shall build it, the standards to be adopted, and the policies to be followed.

Most effected by the new order of course is Federal Works Administrator Carmody, whose control over the program is considerably reduced. Various disagreements over policy and procedures have developed in recent months between the Federal Works Agency and the housing coordinator, disagreements which will now presumably be resolved in favor of the coordinator.

Thus Palmer has placed far more emphasis than have the housing agencies on demountable housing, which can be moved to new locations after the emergency is over. FWA has inclined toward permanent structures, built by USHA.

FWA also has interpreted the Lanham Act, under which defense housing is done, as calling primarily for housing for industrial workers. Palmer has emphasized projects for civilian federal employees and families of enlisted men.

The share of the defense housing job handled by private building is likely to be increased under the new arrangement. Palmer has always had more faith than have the government housers in the possibility of handling the work privately.

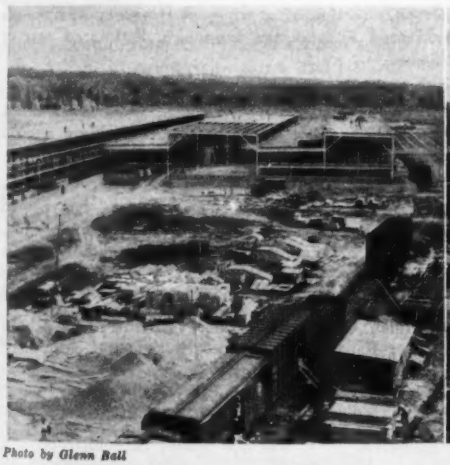

Photo by Glenn Ball

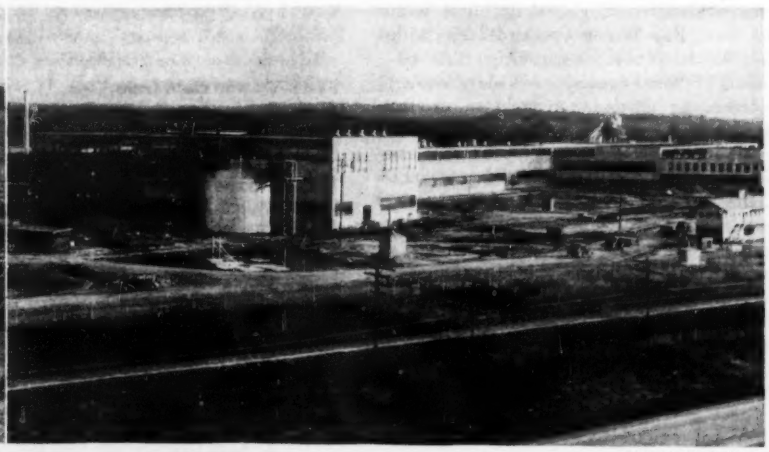

Photo by F. S. Elmore

Rapid work marks construction of Wallboard plant in Mississippi

Construction of a $2,000,000 Flintkote Corp. plant at Meridian, Miss., to provide 230,000 sq.ft. of floor area for manufacturing 65 million board-feet of wallboard annually was begun March 1, 1940. Later plans were changed for a $3,000,000 plant to produce 100 million board-feet each year. How the work appeared Sept. 5 is shown by the aerial view at the left. The rapid advancement since then is shown by the right photograph taken Jan. 1, 1941. The plant is of one- and two-story construction with reinforced concrete floors, steel framing, brick and corrugated asbestos outside walls, and metal roofing.

Rust Engineering Co., Pittsburgh and Birmingham, with J. S. Sides, resident engineer, is the general contractor. George Pecaro is resident manager for Flintkote.

J. I. Ballard rejoins News-Record staff

After an absence of six years during which time he served as editor of *Western Construction News* in San Francisco, J. I. Ballard has returned to the staff of *Engineering News-Record* as managing editor. Mr. Ballard first entered editorial work in *News-Record's* San Francisco office in 1929, becoming Pacific Coast editor in 1933, and transferring to the New York office in 1934. He went

J. I. Ballard

back to San Francisco as editor of *Western Construction News* in 1935. His new duties again bring him to New York.

A graduate of North Dakota State College in civil engineering, Mr. Ballard took graduate work at the University of California. This was followed by six years of engineering activity, first with the East Bay Water Co. and later with the W. L. Huber, consulting civil engineer of San Francisco. Widely known to engineering and construction circles on the Pacific Coast, both through his writing and his activities in technical societies, Mr. Ballard was elected president of the San Francisco section of the American Society of Civil Engineers for the current year. In this capacity as his last official duty, he is attending the Am. Soc. C. E. annual meeting this week in New York as the representative of the San Francisco section. He has already entered on his duties in *News-Record's* New York office.

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Tallest housing project

The country's tallest low-rent public housing project to provide homes for 1,296 low-income families is to be built in New York City's lower East Side. The central buildings will be 13 stories high and will be constructed with USHA funds.

JOBS OF THE WEEK

SMALL ARMS AMMUNITION PLANT, St. Louis, Mo.

Fruin-Colnon Contracting Co. and Fruco Construction Co., St. Louis, and Massman Construction Co., Kansas City, Mo. have received construction contract for small arms ammunition plant, from War Department, Washington, at a cost of $11,8[illegible],400. Western Cartridge Co., East Alton, Ill., was awarded contract for operating.

SHIPBUILDING PLANT, San Francisco, Calif.

MacDonald & Kahn, Ltd., of San Francisco, has been awarded contract by Bethlehem Steel Co., for new construction at the Risdon shipbuilding plant. Cost is estimated at $1,500,000. Funds were alloted by the Navy Department, Washington, D. C.

BRIDGE, New London, Connecticut

The State of Connecticut has awarded a contract to A. I. Savin Construction Co., of East Hartford, for erecting the substructure for a 6,300-ft. cantilever steel reinforced concrete toll bridge over the Thames River between Groton and New London. Cost estimated at $1,846,995. Harris Structural Steel Co., received the contract for the superstructure, which will cost $2,254,925.

FACTORY, Macon, Ga.

The Reynolds Corp., (Reynolds Metals Co.) of Richmond, Va., has received contract from Bureau of Yards & Docks, Navy Department, for construction of a $1,673,315 plant at Macon, Ga., to manufacture ordnance equipment.

AIRPLANE PLANT, Farmingdale, N. Y.

Brown & Matthews, Inc., New York, N. Y. awarded contract for constructing and designing factory expansion for Liberty Aircraft Products, Farmingdale, N. Y. Cost with equipment is $1,088,000.

AIR FIELD, Spokane, Wash.

Alloway & Georg and Clifton & Applegate, Spokane, has received contract to erect barracks, administration building, warehouses, telephone buildings, radio station, hangar, operations building, guardhouse, and infirmary, for Army Air Base at Sunset Field by U. S. Engineers, Seattle. Estimated cost $1,000,000.

POWDER BAGGING PLANT, Charlestown, Ind.

The War Department has awarded contract to Goodyear Engineering Corp., of Akron, Ohio, for a bag loading plant to cost $3,000,000. Funds for construction, equipment and operations amount to $13,899,541.

ORDNANCE PLANT, Sandusky, Ohio

E. B. Badger & Sons Co., Boston, Mass., has received contract from the War Department for the construction of an ordnance plant to manufacture TNT and DNT. The plant is known as Plumb Brook Ordnance Plant. The cost is $10,725,000. It will be operated by Trojan Powder Co., of Allentown, Pa.

APARTMENTS, San Francisco, Calif.

The Metropolitan Life Insurance Co., has awarded contract to Starrett Bros. & Eken, Inc., New York, N. Y., for the erection of a group of two-story apartments on a 200 acre site in the Lake Merced Area at San Francisco. Estimated cost of the project is $11,500,000.

PENSTOCKS, California

Western Pipe & Steel Co. of California, San Francisco, Calif., were low bidders for constructing four penstocks for Shasta Dam at $1,587,000. Bids were opened by the Bureau of Reclamation, Denver, Colo., January 2.

HOUSING, Manchester, N. H.

The Constructing Quartermaster, First Army Corps., Boston, Mass., has placed contract with Cayne Construction Co., of Brooklyn, N. Y., for erection of housing, barracks and officers quarters at the Manchester airport. Estimated cost is $2,000,000.

SHELL LOADING PLANT, Milan, Tenn.

H. K. Ferguson, Cleveland and Oman Construction Co., Nashville, Tenn., have been awarded a contract by the War Department for construction and equipment of an ammunition loading plant at Wolf Creek Ordnance Works. The cost is $14,000,000. The plant will be operated by Proctor & Gamble Defense Corp.

HOSPITAL, Fort Dix, N. J.

J. A. J. Construction Co., Inc., Brooklyn, N. Y. was low bidder for constructing a one thousand bed general hospital at Fort Dix, N. J. for the Constructing Quartermaster. Bids opened Jan. 6. Cost $1,828,000.

PLANT FACILITIES, Maryland

Cummins Construction Corp., and Riggs, Distler & Co., Baltimore, Md., have received contract for constructing additional plant facilities at Edgewood Arsenal and Aberdeen Proving Ground, for War Department. Cost of the work is $1,130,684.

NOTE—Additional bidding and contract news on over 800 projects large and small appear in the Construction News Section beginning on page 179.

Sanitary field loses three prominent members

WILLIAM LAWRIE STEVENSON, director of the bureau of engineering, Pennsylvania state department of health, died Jan. 4 in Harrisburg. He was 64. A graduate of the University of Pennsylvania, Mr. Stevenson entered the employ of the city of Philadelphia, and from 1898 to 1908, he was actively engaged in municipal problems. Among other things, he drafted comprehensive plan for collection of sewage and supervised construction of the Northeast disposal works.

During the last World War, Mr. Stevenson was assistant director of the U. S. Shipping Board division of health, in charge of water supplies, sewerage and other sanitary engineering work in the emergency shipyard program. In 1919 he became assistant chief engineer of the Pennsylvania department of health, and in 1922 was made chief engineer, a post he held until 1937. After a short period of private consulting work with Metcalf & Eddy of Boston, Mr. Stevenson returned to Pennsylvania in 1938 to accept the post he held at his death.

JOHN BLACKSTOCK HAWLEY, hydraulic and sanitary consulting engineer of Fort Worth, Tex., died Jan. 9, at the age of 74. Mr. Hawley began his career as an engineer for the St. Paul water board, following his graduation from the University of Minnesota in 1887.

In 1889 he moved to Fort Worth where he engaged in private practice for seven years. Mr. Hawley then served as city engineer of Fort Worth until 1907, when he again returned to private consulting practice.

During the World War he was a major, commanding the 503d Engineers of the A.E.F. Leaving the army in 1919 he again went into sanitary consulting work, associated successively in the firms of Hawley & Lands, Hawley and Roberts, Hawley and Freese, and Hawley, Freese and Nichols. The latter connection was terminated in 1938 when Mr. Hawley opened his own office.

LESLIE CLIFFORD WHITTEMORE, chief engineer of design for the Sanitary District of Chicago since 1925, died January 13 in Chicago following an illness of three months. He was born April 22, 1885, at Milford, Mass., and graduated from Massachusetts Institute of Technology in 1907. His early career included two years with the Massachusetts State Board of Health, a short time with the U. S. Government as chemist on water treatment studies, and three years with the New York Board of Water Supply as engineer on tunnel construction. He joined the Sanitary District in October 1912 working up through all departments to become chief engineer in 1925.

Photo by Aerial Surveys Inc.

Cloverleaf solves traffic problem in Cuyahoga River Valley

At the intersection of U. S. Route 21 and State Route 17 in the Cuyahoga River Valley, seven miles south of Cleveland, the above cloverleaf was recently completed, eliminating a bad three-way flow of traffic.

The project is of unusual interst in view of the limited space in which it was constructed. The design includes a grade separation of two highways, two railroad grade separations, one bridge over the Cuyahoga River, on Route 17, and another on Route 21 over a branch of the Baltimore & Ohio R.R., the Cuyahoga River, the Ohio Canal, and Canal Road. Construction involved 200,000 cu.yd. of roadway excavation, 1,000,000 cu.yd. of embankment, and 200,000 cu.yd. of channel excavation for a 3,000-ft. relocation of the Cuyahoga River. Three and one-half miles of pavement were required.

Route 21 (left center to upper right) is carried across the valley on a fill averaging 35 ft., but reaching a height of over 60 ft. where the road crossed the old river channel. This route is carried over the B&O R.R. on a three span, 195-ft. continuous steel beam bridge, and over a branch of the railroad, the Cuyahoga River, the Ohio Canal, and Canal Road on a five span, 583-ft. continuous plate girder bridge. Both of these bridges are on 14-in. cast-in-place concrete piling. The bridge separating the grades of U. S. Route 21 and State Route 17 is a stone faced concrete rigid frame on 70-ft. H-beam piling. The two bridges on Route 17, (upper left to lower right corner), one over the B&O and one over the relocated Cuyahoga River are each 227 ft., three-span continuous steel girder bridges. The railroad bridge is on 14-in. cast-in-place concrete piles, and the river bridge on 12-in. timber piles. All of the bridges are provided with open type, welded steel railing panels set between concrete posts.

In addition to five different widths of pavement being required, 20 ft., 24 ft., 34 ft., 36 ft. and 44 ft., the job also involved the widening of a 30 ft. pavement to 44 ft.

The cost of the project was approximately $1,800,000, and was financed jointly by the state and federal governments. Robert S. Beightler is director of highways; T. W. Kinnear, chief engineer of construction; and Fred R. Williams, division engineer for the Ohio highway department.

Grading work was done by the Herkner Construction Co., paving by the Baldwin Brothers Co., and bridges by the Hunkin-Conkey Construction Co., all of Cleveland.

Ontario to develop more power at Niagara

Plans to spend $40,000,000 on expansion of power development facilities at Niagara Falls have been announced by Thomas Hogg, president of the Hydro Electric Power Commission of Ontario. The commission now is diverting 5,000 cfs., over that permitted by treaty under a temporary agreement entered into last October (*ENR* Oct. 17, p. 508), and plans to ask the United States government to agree to a further diversion of 10,000 cfs. Most of the power is being exported to the United States for the production of ferro-alloys for the British.

The commission plans to build a new 50,000 hp. generating plant at Decew Falls, near Thorold, Ont., using water diverted from the river through the Welland Canal, and if further diversions are authorized it will build a new intake canal around Niagara Falls to Queenston and will build an additional plant there.

Labor shortage survey

Continued from page 67

ers, steel detailers and designers. There seems to be very little migration of engineering workers out of the Kanawha Valley.

In South Carolina the head of the state federation of labor reports that union organizations are able to fill all demands for skilled and unskilled labor. Thousands of workers are flocking to Charleston, S. C., because of the large government construction projects under way there. The group includes many civil engineers.

In Mississippi the supply of civil engineers is just about ample to meet the needs on highway, private and defense projects. The president of the state labor union reports that there is a shortage of skilled and semi-skilled laborers throughout the state.

A boom in Florida

Defense construction and associated work has absorbed most of the available skilled labor in the Orlando, Fla. area. Hotel and apartment construction in the resort centers, industrial and commercial building, home building, and housing are employing skilled workers throughout the state on a scale far in excess of the boom days of past years. Many older civil engineers have returned after several years of idleness. Certain contracting and construction firms are busy for the first time in years, and many new contracting companies have been formed. However, there is no acute shortage of technical men in that area. In the Jacksonville area the army and navy defense projects have drained all cities of skilled labor, such as steel workers, welders, plumbers, construction machinery operators, and masons. Carpenters are sufficient for the most part, and common labor is plentiful, as many older men are getting jobs. There is scarcely an organization in Florida that has not lost professional men to defense work or for military service.

There is no shortage of skilled or unskilled labor in the Birmingham, Ala., industrial area, according to Roy Copeland, secretary of the Birmingham Building and Construction Trades Council. There was a temporary shortage of carpenters at the time army cantonments were being rushed to completion, but this has now abated. There also seems to be an adequate supply at present of civil engineers.

That the national defense program is drawing heavily upon municipal, county and state organizations in the Columbus, Ohio area is the report from that city. Already the Ohio state highway department has had about 80 men leave for national defense work or military training. There is a very definite shortage in skilled and semi-skilled workers in the industrial field. Both Cuyahoga County and the city of Cleveland engineering offices report sufficient skilled labor on hand. The county engineer's office reports 9 civil engineers leaving for defense work or military training.

Demand and supply for construction labor in the Lansing, Mich., area are about equal. The Michigan State Highway Department has lost two civil engineers in the past three or four weeks but replaced them easily. However, the department does not know where it might find men for many more replacements. The civil engineering department at Michigan State College reports many requests for men, but has been unable to locate them so far. The U. S. Employment Service has had no trouble finding construction workers nor placing those looking for jobs.

Conditions are described as satisfactory or normal as to common labor and skilled workers at Chicago with but very little construction actually underway. However, contractors anticipate a shortage in case of any revival of construction in the city. As to engineers, so far there has been little trouble in filling all available jobs, even in the offices of consulting engineers and architects who have large defense projects.

At the Twin Cities very little defense work is being done, and there is no exodus of civil engineers from that area. This includes the Minnesota state highway department staff.

West of the Mississippi

At Omaha no shortage of common labor or of building mechanics is being experienced. There also seem to be plenty of civil engineers available. A few men have left the city and county engineers' offices, but the changes have been few. WPA projects have not been affected much by men going to federal defense work.

Typical of conditions in Arkansas, W. W. Zass, chief engineer of the Arkansas state highway commission, points out "while a number of our personnel have been absorbed in work of this character (national defense) the situation has not been complicated." Likewise, Capt. J. R. Crume, Jr., Little Rock, Ark., district, U. S. Engineers, reports "you are advised that this office has three flood-control dams under construction by contract, and construction of a fourth dam has been authorized. The offices of the contractors involved have encountered no difficulty to date in securing labor in either the skilled or unskilled grades. During the past six months approximately 29 of our civil service employees engaged in engineering work have resigned their positions to accept employment on national defense work."

Although, due to the large amount of defense construction, activity is the greatest in years at St. Louis, there is now enough labor to meet all demands.

Due to the small amount of public work in the Oklahoma City area during the past year, the defense program has absorbed all available skilled labor. The $6,911,000 waterworks program for that city is expected to be hampered by the lack of local skilled and professional workers. The Oklahoma state highway department, operating on a greatly reduced budget during the past year, has sufficient personnel but no men to spare.

Texas supply near demand

A considerable number of building trades workmen have migrated from the Austin, Tex., area to where army camps are under construction, but the exodus has produced no shortage. Local labor officials advise that sufficient workers are available to handle all regular work now underway and any expected future increase. Although Texas firms holding contracts for engineering service have experienced some difficulty in securing men for all engineering positions, this has not been sufficiently serious to cause many men to leave employment of the state highway department.

At San Antonio conditions are briefly as follows: slight surplus of common labor, supply about meeting demand for carpenters, slight surplus of truck drivers and bricklayers, and a definite shortage of good architectural draftsmen. The Texas state employment service reports one civil engineer unemployed; before the defense program began ten to fifteen per cent of the professional engineers of Texas were unemployed.

The available labor supply at Dallas has been sufficient to meet demands, but the large amount of industrial work may cause a future shortage. There has been no serious shortage of skilled workers, nor losses of professional men from the engineer offices of the city and county. However, men with professional training find ready employment, according to Homer A. Hunter of the Dallas engineer's office. Special short courses are helping greatly to meet skilled labor demands.

There has been no marked labor shortage at Cheyenne, Wyo., where nearly $3,000,000 of construction is underway on the replacement center at Fort Francis E. Warren, despite the fact that the Cheyenne Employment Service has found jobs for about 3,000 workers. Skilled workers from other states have been employed to a small degree but only when Wyoming men were not available. No unskilled or common labor has been obtained from outside the state. The Wyoming state highway department during the past year had three draftsmen, three materials engineers, and one resident engineer resign to aid on the defense program or for military duty.

With but one major defense job underway in Arizona, that at Ft. Huachuca employing about 1,000 men, labor conditions in that state are normal.

For the States of California, Oregon, Washington and Nevada, in general there is need for carpenters, cement finishers, structural steel workers, and sheet metal workers.

Twenty thousand more men, if they are available, will be at work on the Seattle, Wash., shipyards and airplane factories, and at the Puget Sound Navy Yard when defense construction in Puget Sound area reaches its peak this summer, according to officials connected with those industries. The state employment service and labor executives declare the men will be available, but employers have their doubts. Jack Bates, state of Washington director of unemployment compensation and placement, insists that there is no shortage of personnel for the Puget Sound defense industries at the present time and that there will be no shortages. F. W. Monreau, secretary of the Seattle Building Trades Council, asserted that there may be a shortage of sheet-metal workers for a short time early this year.

OBITUARY

FREDERICK S. KEELER, 73, of New York, died Jan. 6. Mr. Keeler was supervising architect during construction of the Hotel Astor in New York.

JOHN P. BROWN, 69, of Toledo, Ohio, died Jan. 7. Mr. Brown was a retired civil engineer and for many years was connected with Michigan Central R.R.

JAMES H. THOMAS, 36, died Jan. 6 in Salt Lake City, Utah. Mr. Thomas was a construction superintendent for the Los Angeles aqueduct, the Hart Mountain project at Cody, Wyo., and the Elton bore linking Bingham and Tooele, Utah.

BENJAMIN PICKLES, 86, died Jan. 5 in Ambridge, Pa. Mr. Pickles was superintendent of the American Bridge Co. plant at Ambridge, Pa. He was builder of the Hell Gate bridge, New York City, the Delaware river bridge at Philadelphia, and the old "Honeymoon" bridge at Niagara Falls, N. Y.

GEORGE H. ANGELO, 58, of Hartford, Conn., died Jan. 7. Mr. Angelo was with the city of Hartford, Conn. in the engineering department for 37 years. He was retired on pension March 1, 1940.

PAUL FERNALD, city engineer of Tucson, Ariz. from 1931 to 1936, and for several years a member of the Arizona state board of technical registration, died Jan. 8 at Fort Lyon, Colo.

PORTER W. GIFFORD, 55, died recently at his home in Dallas, Tex. He was a prominent railroad and dam builder, and was president of Gifford, Hill & Co. He directed the building of the Abilene dam, Lueders dam, the Southern Pacific Dallas Belt Line and the Texas & Pacific yards at Dallas.

CLARENCE S. YOUNG, 62, Little Rock, Ark., a civil engineer employed on construction work at Fort Robinson, near Little Rock, died Jan. 4.

JULIEN C. FIELD, engineering contractor of Texas, died Dec. 22 at Denison, Tex.

CLYDE ARTHUR PRAVITZ, of Fayetteville, N. C., died Jan. 3. Mr. Pravitz was WPA supervisor for Cumberland county, N. C.

ROBERT C. TERRELL, 57, of Louisville, Ky., died Jan. 9. Mr. Terrell was city engineer and superintendent of the Louisville waterworks. He was a graduate of the University of Kentucky, department of engineering, and was a former dean of that school, having organized the school of highway engineering at the University. From 1908 to 1912 he was professor of civil engineering, and from 1912 to 1916 was commissioner of public roads for the Kentucky State Highway Department. Leaving the highway department in 1916 he became associate professor of civil engineering at the University of Oklahoma where he remained until 1920. During part of this time he served as Oklahoma state highway engineer.

CONTRACTS AND CAPITAL

ENGINEERING CONSTRUCTION awards for the week, $89,174,000, top their values for the corresponding weeks a year ago for the twentieth straight time. The volume is 116 percent above the 1940 week, but is 43 percent under the high volume of last week.

The increased volume of large-scale privately financed apartment construction in California defense areas brings private construction to a peak 258 percent higher than last year, and 14 percent above last week. Public awards are 65 percent higher than a year ago, but are 59 percent under a week ago.

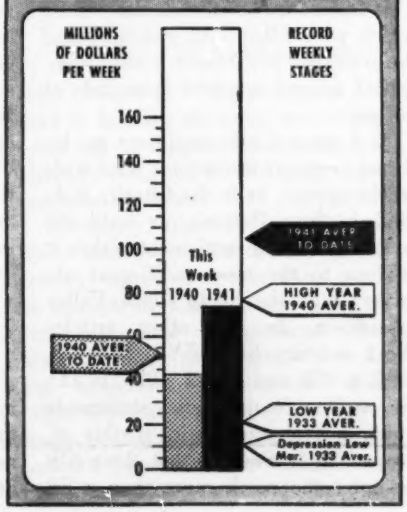
The current week's total brings 1941 construction to $329,541,000, an increase of 107 percent over the three weeks of 1940. Private construction is up 117 per cent, and public awards are up 102 percent due to the 784 percent gain in federal work.

Commercial building and large-scale private housing volume, $32,378,000, tops all its weekly totals since April 14, 1938, as a result of the lettings for apartment projects in San Francisco and Los Angeles. In addition, earthwork and drainage, and unclassified top their last week's totals; and bridges, industrial and public buildings, streets and roads, and unclassified gain over the 1940-week totals.

New capital for construction purposes for the week, $16,989,000, is 160 percent higher than last year. The volume is made up of $15,869,000 in state and municipal bonds, and $1,120,000 in corporate security issues.

New construction financing for the year to date, $50,219,000, is 27 percent below the 3-week 1940 total.

ENR CONSTRUCTION VOLUME



CONTRACTS

(Thousands of dollars)

	Week Ending Jan. 18 1940	Jan. 9 1941	Jan. 16 1941
Federal	$3,169	$88,285	$26,515
State & Municipal	27,440	35,354	23,878
Total public	$30,609	$123,639	$50,393
Total private	10,852	34,184	38,781
TOTALS	$41,461	$157,823	$89,174
Cumulative 1941 (3 weeks)			$329,541
1940 (3 weeks)			$159,299

Note: Minimum size projects included are: Waterworks and waterways projects, $15,000; other public works, $25,000; industrial buildings, $40,000; other buildings, $150,000.

NEW PRODUCTIVE CAPITAL

	Cumulative 1940 3 weeks	1941 3 weeks
NON-FEDERAL	$68,933	$50,219
Corp. Securities	9,854	5,738
State & Mun.	13,880	30,818
U.S.H.A. loans	45,199	12,043
R.F.C. loans	.....	1,620
FEDERAL	.....	.....
TOTAL CAPITAL	$68,933	$50,219

FHA MORTGAGES

	Week Ending Jan. 13 1940	Jan. 4 1941	Jan. 11 1941
Selected for appraisal	$15,244	$12,997	$17,767*
Cumulative 1941 (2 weeks)			$30,764*
1940 (2 weeks)			$29,397

* Subject to revision.

ENR INDEX NUMBERS

Index Base=100		1913	1926
Construction Cost	Jan. '41	249.69	120.03
Building Cost	Jan. '41	207.94	112.46
Volume	Dec. '40	344	151

Comment and Discussion

Readers' opinions on matters that concern engineers and contractors

Storm King Highway

Sir: I note the editorial in your issue of Sept. 26 referring to the Storm King Highway and I think your conclusions were based on an inadequate appreciation of the factors and circumstances of the case.

I made a critical examination of this whole situation some two years or so ago and I think it is greatly to be regretted that the old road was not improved instead of building a new one. The old road is one of the great scenic highways of the world, which the new one is not.

It has been officially stated that the old road is to remain in service, so the danger from rock slides still exists, unless adequate precautions which are entirely practical are taken.

The faults of the old road could have been corrected and it could have been widened at much less cost than that of the new road, and now both roads have to be maintained. The steep gradients on the new road and its location expose it and the traffic to more danger from ice and snow than is the case on the old road, and the new road is not exempt from rock slides.

If and when the through traffic on this route should have warranted a new location, the present route is not the best which might have been chosen for a through route between Bear Mountain Bridge and Newburgh. In my opinion the expenditures for the new road are not warranted and the location is not economically sound.

F. Lavis
Consulting Engineer
New York, N. Y.

Sir: When Fred Lavis criticizes your editorial of Sept. 26 and our new Storm King Highway by stating that the new road is not scenic, he shows that he has not seen this improvement or enjoyed the magnificent views of the Hudson and West Point, which may be seen from convenient parking places along the road.

If he will take time to make another critical examination of this area, he will discover that this road does not confirm the dark forebodings which he expressed after being retained by a group of wealthy people to block the construction of the new highway on the route selected by the state.

J. S. Bixby
District Engineer
Department of Public Works

Structures on Landfill

Sir: The landfill method of refuse disposal (*ENR*, Dec. 5, 1940, p. 764) may be very satisfactory from many standpoints, and it is of unquestioned value for converting marsh lands into park areas. But since the material in these fills is largely organic, it is only a question of time until the material will become a peat. And every foundation engineer knows that peat is the most compressible of all materials.

While these fills may become stable under their own weight, additional surface loads will cause a rapid settlement, the magnitude of which will depend upon the depth and character of the fill as well as upon the magnitude of the additional load. The writer has in mind the case of an oil tank failure which was caused by settlement, which in turn was due to the presence of a one-foot layer of waste from a mattress factory which had occupied a part of the site in bygone days. As the tank was being filled with water for testing, one side went down under the load until the tank burst. This failure burst other tanks nearby which were filled with gasoline, and the resulting fire caused a total damage of several hundred thousands of dollars.

As a general rule, engineers are inclined to ignore settlements until wide cracks appear, as in the Charity Hospital in New Orleans, or until the magnitude of the settlement makes it obvious to the most indifferent observer; e.g., the Santa Clara Valley subsidence. In two other articles about sanitary fills (*ENR*, Nov. 23, 1922, p. 876 and July 2, 1925, p. 11) the writer found these statements which are characteristic of this attitude: "It is asserted that these fills do not settle much more than a fill made entirely of earth . . .", and a residence founded on an old sanitary fill ". . . showed no evidence of settlement." If the simple expedient of running levels from a reliable benchmark had been resorted to, quantitative evidence instead of opinion could have been presented.

In view of the growing tendency on the part of engineers to design and build more rigid frames and continuous girders and trusses, such indifference to settlements is very reprehensible. And such articles as these lend tacit encouragement to the unwarranted hope that if the superstructure is adequate for the design assumptions, all will be well, regardless of what is below the surface of the ground.

John D. Watson
Assistant Professor of Civil Engineering
Duke University, Durham, N. C.

Uniformly Tapped Pipes

The following discussions refer to the article Loss-Of-Head Determination in Uniformly Tapped Pipes, *by R. D. Gladding,* ENR *Nov. 21, 1940, p. 697.*

Sir: The characteristics of a manifold have been disregarded in developing the loss-of-head formula in the article. The author assumes "that outlets are evenly spaced along a line and each outlet discharges the same quantity . . ." This is neither possible, nor does it represent a close approximation of actual conditions except for a pipe having a very large area compared to the outlets.

In the direction of flow, velocities are reduced after passing each successive outlet. A rise in pressure accompanies this reduction in velocity. Except in specially designed outlets, data indicate that the efficiency of the downstream outlets is increased because of the lower transfacial velocity. These factors cause each successive outlet downstream to discharge a greater quantity. The differences in discharge are so large that they should not be neglected even in an approximate analysis.

F. W. Edwards
Senior Hydraulic Engineer
The Panama Canal Zone
Diablo Heights, C. Z.

Sir: In reply to Mr. Edward's comments may I say that the purpose of the article was to present a simple means of approximating the loss of head under the conditions imposed in

the derivation. I believe that its use without modification will give results within the limits of ordinary hydraulic precision. It is felt that the recovery of pressure at each outlet is relatively unimportant when compared with assumptions made by the designer in the selection of pipe categories, formulas, etc. The formula is merely a refinement of the usual one given in textbooks such as Merriman, for uniformly tapped pipes, where the factor F is given as $\frac{1}{(m+1)}$.

Allowance for reduction in transfacial velocity and its effect upon nozzle discharge would be difficult to determine. There may be published data to guide in this determination, but it is not available to me. My experience and observation, however, have led me to believe that the nozzles discharge progressively less as the end of the pipe is approached, especially when small mains are used.

If the *average* discharge is not desired, but a minimum discharge at the end nozzle is required, an *approximate* discharge for the first nozzle may be obtained from the fact that discharges are proportional to the square root of the pressures. In the example in the article, assume that the pressure at the end of the line is 20 psi., at which pressure the nozzle discharges 20 gpm. The same size nozzle at the beginning of the line would then be under a pressure of roughly $20 + (0.433 \times 7.13) = 23.1$ psi. and its discharge would be approximately $1.07 \times 20 = 21.5$ gpm. The new average discharge would be close to 20.8 gpm or a total in the line of 208 gpm. (This is not strictly true because the pressure gradient sags parabolically and is not a straight line; however, it is on the side of safety.) With this new total discharge a new approximation can be made, and so on until satisfactory agreement is reached.

I believe it would be of interest if the same problem were worked out by more exact methods, making allowance for pressure recoveries at nozzles, etc., and compared with this solution.

R. D. GLADDING
In Charge, Water Facilities Program
Soil Conservation Service
Spokane, Wash.

Sir: A sprinkling filter for sewage disposal was named as an example in which the author's formula for loss of head in a pipeline was applicable. Here the spacing of nozzles and discharge of water therefrom is an important function by which uniform distribution of sewage on the filter bed is achieved. Let us examine the example given by the author, namely, a 4-in. pipeline having 10 uniformly tapped outlets on 40-ft. spacing, each of which is said to discharge an *average* of 20 gpm.

The computed loss of head due to friction only in the 4-in. pipeline, using Williams-Hazen $C = 100$, is 7.13 ft. by the author's method on the basis that the same amount of water is discharged from each outlet. But the nozzle outlets, according to the paper, are uniformly tapped and for illustration we will assume that they are 1¼-in. pipe size. The total loss of head through each nozzle would be approximately $2.5\frac{V^2}{2g}$. Then by trial computations the individual discharges through the 10 uniformly tapped outlets would be as follows:

Nozzle No.	Nozzle Discharge gpm.	Pipe Flow Total gpm.
1	42.1	209.0
2	33.7	157.9
3	27.0	124.2
4	21.7	97.2
5	17.6	75.5
6	14.3	57.9
7	12.3	43.6
8	11.1	31.3
9	10.1	20.2
10	10.1	10.1

The above tabulation shows that the amounts of water which will be discharged through 10 uniformly tapped outlets will vary widely from more than twice the 20-gpm. average at the first outlet to half the average at the last one. Computed total friction loss in the 400-ft. run of 4-in. pipe on the above basis would be 4.72 ft. plus the No. 10 nozzle loss $2.5\left(\frac{V^2}{2g}\right)$ of 0.18 ft. which makes a total of 4.90 ft. This compares with 7.13 ft. loss for the same run of pipe when all 10 outlets have been individually designed to discharge equal amounts of water.

Obviously, the author did not mean that the outlets would be uniformly tapped nor that they would be spaced far apart in sprinkling filters but these comparisons draw attention to the importance of avoiding erroneous conclusions which might arise as a result of the limited scope of the paper. Therefore, the author's formula should be used only with due consideration of the practical aspects of the problem as a whole, especially in its application to trickling filters where the available hydraulic head is frequently limited and uniform distribution of sewage on the filter bed is essential.

FREDERICK C. ZEIGLER
125 Worth St., New York, N. Y.

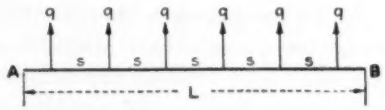
Sir: I would like to present a few minor corrections and additional suggestions on the use of Mr. Gladding's formula. In the second column about the middle of the page the expression reading:

Loss-of-head $= (N/N^{m+1})KL$

should read as follows:

Loss-of-head $= (N/N^{m+1})KLQ^m$.

Also in the third column the expression reading $\frac{2N^3 + 3N^2 + 1}{6N^3}$ should be $\frac{2N^3 + 3N^2 + N}{6N^3}$ making the next expression $F = 1/3 + 1/2N + 1/6N^2$ instead of $1/3 + 1/2N + 1/6N^3$.



Referring to his Fig. 1, if the outlets are spaced so as to include a half-section at each end as shown in the accompanying sketch, the expression for F becomes $1/3 + \frac{1}{6N^2}$ where $m = 2$. When N is greater than seven in this expression for F, omission of the term $\frac{1}{6N^2}$ will cause an error no greater than one per cent. When m is less than two, the corresponding correction becomes even more negligible. Thus if these outlets are spaced so that there are half-sections at the ends, the friction head loss can often be considered to be equal to $\frac{1}{m+1}$ times the friction head loss of a corresponding pipe with no take-offs.

It is to be noted that the outlet flows have been assumed to be equal. This equality of discharge rate could only be accomplished in full discharge by appropriate variations of the discharge characteristics of the outlets. Furthermore, the head loss is not the same as the change in pressure because pressure recovery at the take-offs resulting from velocity changes are often of great importance.

W. E. HOWLAND
Associate Professor of Sanitary Engineering, Purdue University, Lafayette, Ind.

EDITORIALS

VOLUME 126 NUMBER 3

January 16, 1941

Labor Makes a Promise

BOTH CONTRACTORS AND WORKERS on defense construction got a lift last week when a policy of no strikes and a limit on initiation fees was announced by nineteen unions of the Building and Construction Trades Department of the AFL through its president, John P. Coyne. And since Mr. Coyne has won high standing among contractors for his fairness, integrity and capable labor leadership, the announcement will be taken as a binding pledge. In the past promises made by a union were too often mere tongue-in-cheek resolutions, quickly forgotten, but beginning with the AFL-AGC agreement to outlaw jurisdictional disputes several years ago a much better relationship has grown up. This has now borne fruit in the promise to give all aid to defense construction work. The building trades deserve high commendation for their promise to bar strikes. In implementing the promise further it is to be hoped that the unions will take radical measures against initiation fees which in general are too high, considering the short tenure of defense construction jobs. Organized labor is seeking representation on all defense councils. It is, in cases such as cited here, pledging its aid to all-out efficiency. It can go a step further and assume equal responsibility with management for the successful prosecution of the defense program which depends, among other things, on fair treatment of the working man. High initiation fees are a place where a beginning can be made.

The Rivers Are Uncle Sam's

WHEN A MAN DIES after a lingering illness, even though he once was strong and hearty, no one is shocked; his passing had been anticipated. Much the same thing can be said of the passing a fortnight or more ago of the once sturdy theory that the federal government's control over water power is limited to navigable streams. When the Supreme Court, in reversing a lower court in the long-famous New River case, put an end to that theory, no one was surprised; that the court would find some way to extend federal control to the headwaters of every major river was a foregone conclusion. The groundwork had been laid by innocent-looking amendments to the Water Power Act of 1920 and by the Flood Control Act of 1938. The effect of the Supreme Court's decision on future water power development is obvious; within fifty years, the recapture period under the Water Power Act, all new projects and many existing developments will be publicly owned or subject to purchase at the will or convenience of the federal government. The effect of the New River decision on other matters such as control of pollution of our rivers is not so apparent, but it is probable that such work also will pass from state to federal supervision, not because the decision amplifies federal control but because it will be difficult to maintain state jurisdiction in the face of expanding federal control over navigation, water power and flood control, especially on streams that lie along state boundaries. From now on the rivers, little as well as big ones, belong to Uncle Sam. Whether the net result is good or bad remains to be seen.

Bomb-Resistant Structures

HAVING MEASURABLY MASTERED proper principles of wind-resistant and earthquake-resistant construction, structural engineers, judging by their questions, are beginning to think about the problem of resisting the explosive forces of bombs. Surprisingly few data are available. At intervals, however, the British Ministry of Home Security issues a report that throws some light on the question. The latest of these, Bulletin C8, discusses structural damage to single-story factory buildings and emphasizes three points: (1) Building should be fully framed rather than being of wall bearing type; (2) framework should be as continuous as possible both at beam-to-column and beam-to-beam connections; and (3) walls should be built of light materials that will blow out under internal blast without damaging the framework. Another British report, relating to heavier buildings, suggested that thick roof slabs, which would either detonate the bomb or crack its shell before detonation, are advantageous in reducing damage. Direct bomb hits on buildings encompassing these design principles have seldom caused complete destruction, it is reported. They are principles which are by no means foreign to good construction, yet the experience records from abroad give them significant emphasis. Bomb-proof, like tornado-proof, structures may be unattainable from an economic or practical standpoint, but bomb resistance is apparently a quality that the structural engineer can supply.

Military Road Policy Needed

CONGRESS should give early attention to formulating a road policy that will make it possible for the states to meet the new demands created by the nation's defense program without neglecting urgent commercial needs. Lack of such policy has slowed up much normal work that ought to be under way and has prevented a start on construction of hundreds of miles of road needed to serve the army cantonments.

Three major road problems are raised by the preparedness program. They are: how to finance the construction of access roads to the new army camps; how to prevent serious congestion around plants engaged in military orders; and how to bring a system of strategic highways up to military requirements without neglect of normal commercial needs. These problems are considered in detail in this issue. No one of them can be solved without some further action by Congress.

MOST URGENT and by far the simplest problem is that of camp access roads. It can be solved quickly by the appropriation by Congress of funds to build the roads. Adequate roads to let men and supplies move to and from the camps freely should be just as much a part of the cost of the training program as building barracks.

Less widespread but quite serious where it exists is the matter of congestion around large plants with war orders. Federal responsibility here is not so clearly defined because the benefits, in most instances, have permanent value. Consequently, it would appear that Congress might meet the problem by setting up a special fund from which expenditures by states or cities could be matched on a 50-50 basis; or on a 75-25 basis where it can be shown that work now needed would not normally be required for many years.

THE THIRD PROBLEM, that of bringing the strategic network up to military requirements within a reasonable time, is not so urgent but is more generally troublesome because of the way it has upset all highway construction programs. When Congress passed the highway act last year it instructed the Commissioner of Public Roads to use his influence to have federal-aid highway funds spent on the strategic network, but it did not lay down any policy to guide him. In some states, concentration of most or all federal aid on the defense system works no special hardship because the roads needing reconstruction to meet commercial requirements are part of the defense system. But in others it raises a serious problem, either because concentration of work on the defense system will leave urgent commercial needs on other roads unfilled, or because the military standards are so much higher than those now built into the roads to meet normal commercial needs as to call for a reduction in the mileage that can be built each year. Such reduction cannot well be made.

Many state highway departments believe that if the federal government wants them to build to higher standards than are required for their commercial needs the government should provide the added cost over and above normal federal aid. Some go so far as to hold that the federal government should bear all the cost of building roads classified as part of the strategic network, not noting, perhaps, that this would merely be the first step toward complete federalization of all main highways.

SOUND POLICY would appear to call for the immediate appropriation by Congress of sufficient money to build the camp access roads. Added to this should be a separate fund which could be used by the Public Roads Administration to supplement expenditures by states, counties or cities for roads to serve war industries. For the strategic network there should be a second federal-aid authorization, extending over a period of several years, that will provide funds to assist the states in building those sections of the network that obviously should have priority. Highways along the seaboards and those serving the ports and key industrial centers fall into this class. Farther inland, where military requirements are less pressing, the requirements should be relaxed wherever they tend to cut down the mileage of commercially serviceable roads that can be built.

Such a financial program would meet military road needs as they now exist. It would remove the stalemate that has held roadbuilding back. And it would prevent useless spending of money on work not urgently needed. It is a program that deserves immediate attention in Congress.

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Modern design practice finds clear expression in this new California highway (U. S. 101) along the Pacific Coast north from Santa Monica. By providing ample paved surface, wide shoulders and easy curves, it serves adequately both for normal and military needs.

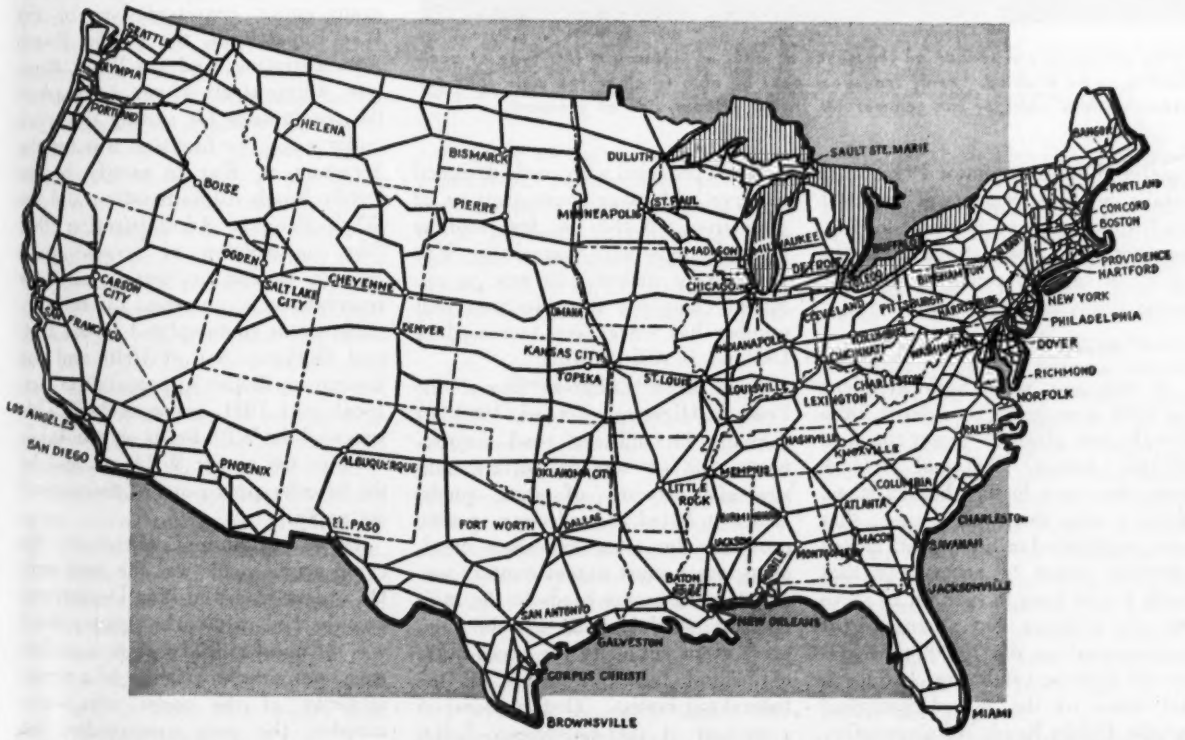
Defense Roads in the 1941 Program

***Contents in Brief**—Access roads to military camps are expected to call for a large amount of highway construction in 1941. No spectacular developments in defense roads are anticipated but the system will be advanced by concentration on it of as much as possible of the regular federal-aid money. WPA funds are expected to aid on local road work. Traffic congestion on roads and streets approaching plants having defense contracts presents a problem for which no solution has been found. Highway widening at such points may become a factor late in the year. Construction of superhighways as defense projects with federal funds appears highly improbable.*

THE YEAR 1941 opens with great uncertainty as to what the year's roadbuilding program is to be. It is clear that roads to serve the military training camps should hold first place on the program if the army is to be out of the mud by summer, but no one knows where the needed millions to build these roads are to come from. Similarly, the state highway departments have been told that federal-aid funds are to be concentrated as far as possible on roads designated as part of the strategic highway network, but Congress has laid down no policy to guide the Public Roads Administration in deciding how to answer the knotty questions that have been raised in many state highway departments while attempting to concentrate expenditures on defense roads and at the same time meet other needs. This is clear: until Congress appropriates money for camp access roads little can be done to correct a condition that grows worse daily.

That Congress will appropriate money for such roads soon after it opens its new session is expected in Washington. By then Congress will have before it the report of the Public Roads Administration on military roads, a report that is known to be centered on the matter of camp access roads. Thus it seems highly probable that construction of roads into military camps will hold first place on the roadbuilding programs of the states for 1941.

In second place, in so far as urgency is concerned, are access roads to new and expanded industrial plants handling defense contracts, but how much actually will be done on them is uncertain. In view of the fact that federal responsibility for their construction is not as clear cut as is its responsibility for camp access roads, the chance that such work will take any conspicuous place in the 1941 roadbuilding problem is remote.



General routes selected by the War Department for a system of highways needed for national defense. The War Department does not name any highway specifically as a military road; it indicates general routes and leaves final determination of the specific highway to the Public Roads Administration and the state highway departments.

On the 75,000-mile strategic network of defense highways little other than continued planning was done in 1940, but there are many indications pointing to much more definite progress in 1941. This much is certain: a large part of the regular federal-aid money will be spent on such roads during the next twelve months. No curtailment of those funds is anticipated.

This, briefly stated, is the place that defense roads will hold in the roadbuilding program for 1941. More details on these elements of the 1941 road work are given in the following, together with observations as to the place of superhighways and city access roads in the program.

Photo by U. S. Army Signal Corps

Wide shoulders are needed on thousands of miles of highway if this type of accident is to be avoided. Army transport must be able to clear the main road for other military units or for commercial traffic without risk of accident.

Access roads to camps

A year ago, when highway plans for 1940 were being considered, little thought was given to access roads to military camps. National defense plans then were in the abstract stage. Military men knew, of course, that many established military posts lacked adequate means of access and that roads would have to be built to serve the new airbases, but attention still was centered on the 75,000-mile system of defense roads that had been laid down by the War Department and the Public Roads Administration as an objective on which to concentrate available funds wherever such expenditures would meet both commercial and military needs. The nation, in short, still was thinking in terms of what roads would be needed to protect it against outside attack.

Appropriations of vast sums for ships, airplanes and military equipment, passage of the Selective Service Act and calling of units of the National Guard into federal service completely changed the situation. The last two acts meant that many military camps scattered over the country would have to be built, chiefly at sites not now provided with roads designed to serve such large concentrations of population. Within a few months after the acts were passed the War Department named 130 new or enlarged camps as its objective; that number has since been increased to 150 and is still growing.

Even when Congress passed the Federal Highway Act of 1940 its thinking on military road requirements still was centered on the main strategic network of state roads. Hence it failed to make any specific provision for what has since developed into a most urgent matter, construction of access roads to the military camps. Only indirectly did Congress grant authority for expenditure of federal funds on roads off the federal-aid system. That is found in a section of the Emergency Relief Appropriations Act which authorized the Works Projects Administration to spend its funds on work needed for the defense program and which liberalized existing WPA restrictions with respect to funds spent for other than labor. Congress did authorize the Public Roads Administration to give priority to defense requirements in allocating federal-aid funds to the states, but as few camps are on the federal-aid system this authority has been of limited usefulness.

Some camps are on secondary roads, but the federal-aid funds for such roads that go to any one state are small. Consequently the burden of much of this work has fallen or will fall on township and county authorities whose funds are limited. Thus by mid-October, when the seriousness of the situation began to be apparent, and when Congress was in no frame of mind to pass more emergency legislation, the WPA was placed in the position of being the only agency having federal funds in any substantial amount that could be used quickly to build access roads to military camps. And its available funds were far from adequate.

Close coordination

As soon as it was discovered that access roads to the new or enlarged camps were to be such an important element in getting the defense program going, representatives of the War Department, the Public Roads Administration, and the Work Projects Administration met to explore the possibilities for getting the work under way. The first step was for the Secretary of War to certify to the Public Roads Administration and the Work Projects Administration that "the construction of access roads leading to and on certain military reservations is important for military purposes as contemplated in the Federal Highway Act of 1940 and the Emergency Relief Appropriation Act, fiscal year 1941, respectively." This removed the WPA limits on non-labor costs of the earlier WPA act and let the broader provisions of the current act apply.

Decentralization of control over the camp access roads was the next step. On orders from the War Department and the Federal Works Agency there was set up at military posts a conference committee consisting of a representative of the corps area commander, the post commander, the post quartermaster and the constructing quartermaster, the district engineer of the PRA, a representative of

the state highway engineer, the director of operations of the state WPA, and representatives of the local governmental agencies concerned.

That was early in November. These conference groups were instructed to determine the reasonable need of the various camps for access roads, the kind and amount of assistance that the PRA and the state highway departments could provide in the way of actual road construction, and the kind and amount of road work that could be done by WPA. Each group was then to weigh how the proposed work fitted into the plans of the constructing quartermaster for roads inside the reservation. The conference groups were advised that practical solutions rather than ideal ones were sought and that the construction of entirely new roads off the military reservations was to be avoided wherever possible because of the difficulties and delays involved in acquiring right-of-way.

WPA road work

Where no other solution can be found, the WPA may at times be able to put up 100 percent of the construction cost. There is no fixed rule as to what percent it puts up, but the restrictions placed by law upon the WPA's expenditures for other purposes than wages make it necessary for sponsors to provide as much money and material as possible. The WPA must still have sponsors, but the requirements of sponsorship may be modified to meet the sponsor's financial situation. Because of the movement of skilled labor from the relief rolls that began with inauguration of the defense program, WPA may write into the sponsor's agreement a provision requiring the sponsor to supply the necessary skilled trades if a shortage develops. These men will be paid normal wages and worked normal hours. WPA men can be worked staggered shifts in order to maintain properly balanced work schedules.

Standards to be applied in building camp access roads are supplied by the Public Roads Administration. That agency, under Congressional authorization to make surveys required by the military road program, has financed many of the necessary surveys for these projects. Field work was done in large part by the state highway departments.

The work that has been started under this arrangement is limited and can best be characterized as an emergency accomplishment due to the limited funds that are available and to other obstacles. At some points where the WPA has undertaken to build needed access roads it has been handicapped by the fact that camp contractors have stripped relief rolls of most of the better men and so have slowed down its operations considerably. The roads that are being improved generally are existing ones that bear little or no relation to the real needs of the camp. They meet construction requirements poorly in most instances and it is obvious that when thousands of troops are concentrated in the camp the traffic congestion will be so bad as to interfere seriously with the efficiency of the camp.

Work at the new military camps is being delayed by lack of adequate access roads. This shows the access road to the 7th Corps Training Center at Newburg, Mo. It must carry trucks of supplies and construction equipment.

Much work needed

In its study of camp access road requirements the Public Roads Administration looked beyond these emergency measures. Its plans and estimates are based on the construction of adequate roads, properly located with respect to both camp needs and existing main roads. The new roads are laid out to permit a reasonably free flow of traffic to and from the camps and the widest possible dispersion of the camp traffic over the connecting highways. The PRA study shows that 3,112 miles of road costing $202,000,000 will be required, of which 1,871 miles are outside military reservations and 1,241 inside.

The chief drawback to putting the Public Roads Administration's plan into effect is lack of funds. All WPA funds cannot be put into such work, and if they could, the limitations put by Congress on their expenditure for equipment would retard prosecution of the work. Also, prosecution of the work through such devious channels is not in line with the urgent need for speed in getting the roads built.

Nor are there adequate local funds available. As noted previously, the PRA can use its influence to get states to concentrate their federal-aid funds on those sections of the federal-aid highway system that have been declared by the War Department to be necessary to the defense program. But that provides only a partial answer to the problem because most of the camp access roads are off the state highway systems; they are county or township roads. And county or township officials see no reason to spend their limited funds on roads that probably will be temporary, especially when traffic developed by the camp construction already has greatly increased their maintenance expenditure. They hold that Uncle Sam should build the roads just as he builds the camp.

The same is true of the states. With good reason, they have not been receptive to diversion of funds that are

badly needed for permanent work into such temporary construction. In many states these funds are needed to rebuild main roads that are part of the main defense highway network. In other states the most urgent needs are for roads not even on the strategic network.

As a consequence of this lack of funds the year 1940 closed with little being done toward solution of the first major highway problem raised by the defense program. However, road authorities believe that there is now little reason to doubt that Congress will take up the matter early in the new session and that the War Department will urge the prompt appropriation of sufficient money to build adequate roads. Once that money is appropriated strong pressure will be brought to bear on the Public Roads Administration and the state highway departments to get the work completed as quickly as possible. Thus all indications point to camp access roads as the major roadbuilding task of the early part of the year 1941.

Access to war industries

Congestion at the rapidly expanding plants of war industries is the second major road problem. Already it is causing costly delays around airplane plants; it is rapidly becoming serious at shipyards, steel mills and many other plants and will grow worse as the defense program approaches its peak. Some relief will be provided by the federal government's efforts to spread the defense work widely over the country and by the tentative plans to farm out much of the work to plants not now engaged in war work. On the other hand, establishment of new industries in places where they do not now exist will make new traffic problems in those regions.

What is to be done about congestion around defense industrial plants is complicated by the fact that part of it is on streets under the jurisdiction of cities and part is on roads or streets controlled by state highway departments. Some elements of the problem that it presents are discussed elsewhere in this issue. All that needs to be said here is that its solution appears so remote as to force the conclusion that it will produce little actual construction, certainly not until late in the year. Only where WPA funds still are available for work under local sponsorship will there be any continuing operations such as pavement widening and shoulder building on highway around plants engaged on defense orders.

Highways for defense

After a year of little action it appears at the opening of 1941 as though a program for step-by-step completion of the 75,000-mile strategic highway network will take definite shape in the near future. This conclusion rests on two facts: first, the War Department has given the Federal Works Agency its approval of a plan showing the general routes along which strategic highways should be provided; and second, the Public Roads Administration now has Congressional authorization to use its influence to have federal-aid funds concentrated on defense. If necessary it can use its power to withhold federal allotments until state programs are fitted to the defense program.

Pressure groups that have tried to get the War Department to approve a specific route as a necessary part of the defense program are largely responsible for the department's long delay in giving the PRA an outline of a strategic highway system that it believes should be brought up to at least the minimum standards set for such a system. The War Department has not and does not expect to give its approval to specific routes; it simply indicates between what points it needs a highway or highways and leaves final decision as to the route up to the PRA and the state highway department concerned.

The general route-indication map approved by the War Department is reproduced in one of the accompanying drawings. It differs little from the one reproduced on these pages a year ago as being under consideration at that time. From it the Public Roads Administration has prepared a confidential map of routes best suited to meeting the War Department's needs. This map, in turn, forms the basis of the PRA's negotiations with state highway departments as to what work should be given priority.

Work required

Study of the strategic highway system as laid down on the Public Roads Administration map shows the items listed in the following tabulation as work required to bring the 75,000-mile network up to minimum standards of a 22-ft. pavement (24 ft. where traffic volume may be large) sight-distances of at least 650 ft., 9,000-lb. wheel loads, bridges at least 18 ft. wide and designed for H-15 loading (15 tons with a load factor of four).

Rural bridges of less capacity than 15 tons	2,400
Bridges with horizontal clearance less than 18 ft.	1,700
Bridges with vertical clearances less than 14½ ft.	150
Mileage of roads surfaces less than 18 ft. wide	5,000
Mileage of road surface needing strengthening	14,000

This is a sizable program. Under normal expenditures, allowing for the fact that not all state and federal funds can be concentrated on these roads, ten years will be required to complete the work. Unlike the access roads to camps, it is not work on which other elements of the defense program are directly dependent, hence the Public Roads Administration is not urging speed where speed will increase costs. Further, the PRA holds that on our main highway system the civilian needs still are superior to military needs, also that wherever congestion exists due to normal commercial traffic any construction to serve such needs will serve military needs equally well.

By-passes and superhighways

That roads built to eliminate congestion in the flow of normal traffic also will serve military needs is especially true of by-pass routes around congested urban centers. The relief to normal traffic provided by such highways is so evident that there is no need to demonstrate their military value. But by the same token little support can be found in military circles for plans to have the federal government build such roads under the guise of military necessity. Where they are built they will have to be built by normal methods of financing, hence no unusual amount of such work can be expected to be put under contract in 1941.

The same is true of limited-access superhighways like the Pennsylvania Turnpike and the projected Boston-Washington superhighway. Unless private capital, on the showing made by the Pennsylvania Turnpike, can be induced to put up money for extension of that road to Philadelphia or for the construction of similar toll roads elsewhere, few if any such projects will get under way in 1941.

And it should be remembered that the federal government put up 45 percent of the cost of the Pennsylvania Turnpike as a PWA grant. Such money is not now available and hardly will be with employment rising under defense orders.

City access roads

City access routes are another part of the strategic military network that cannot be expected to make any abnormal progress in 1941. Efforts were made in the last session of Congress to write into the 1940 highway act a provision authorizing the RFC to make loans to states or to the Commissioner of Public Roads for purchase of right-of-way for such roads, the states to repay the loans on an annual basis over a period of 40 years. No bonds were to be issued. This Congress declined to do; it did, however, write in a provision authorizing the RFC to make loans to states for right-of-way purchase when the loans are supported by adequate security. As the RFC already has such authority, this provision does little more than give specific recognition to the urgency of the matter of providing better city access roads.

The need for city access roads grows daily, but no simple way to provide them is at hand. With city debt limits as high as they are there is small prospect that the cities will put up the needed funds or the security for an RFC loan; nor are states inclined to put up funds for what rural legislators consider essentially a city problem. Thomas H. MacDonald, head of the Public Roads Administration, looks on city access roads as one of the most important elements of the program, hence it is to be expected that any move to expedite such work will have his support.

Bridge construction

No abnormal bridge construction is anticipated for 1941. The PRA survey shows that 2,400 bridges need strengthening to bring them up to standards set for the military highways, but as the state bridge reconstruction programs for 1941 largely have been made up, little increase in such work to meet the deficiency can be expected until 1942.

Alaska highway

More remote than any of the highway prospects discussed previously is the possibility that the long discussed Alaska Highway will get any federal funds on the ground that it is of military value. As one high army officer put it, "so long as we can send ships up along the Pacific Coast to Alaska there is no need for the highway, and if we lose control of the Pacific a single highway across the wilds of northern Canada and Alaska would be of no use in defending Alaska."

What is true of the Alaska Highway is equally true of the Inter-American Highway through Central America. It has no military value that would justify diversion of funds from more necessary work.

The prospect for 1941

Funds for normal highway work in 1941 have been provided, and that work will go ahead about as usual, the major change being in concentrating expenditures on roads that form part of the military network. The President's statement of last fall with respect to cuts in federal appropriations for work not actually part of the defense program is believed to have little bearing on federal-aid road work. What he said about road work is believed to have been said chiefly for the benefit of those who hope to get federal funds to build pet highway projects that they hold to be military necessities. That Congress will appropriate a considerable amount of money for camp access roads seems highly probable although it may not amount to the $200,000,000 that the PRA estimates will be required. This money may be made available soon and, if it is, fast action will be required. Hence the spring and early summer of this year should see a large amount of road work scattered quite widely over the country.

Highways of the strategic network must be able to carry field pieces such as this 155-mm. gun, and have sufficient width to keep the guns from blocking other traffic.

Photo by U. S. Army Signal Corps

Fig. 1. New four-lane highway through Fort Custer, Mich., built by the state. Roll curb and gutters are not yet in place.

Michigan Builds Camp Access Road

***Contents in Brief**—Under a regular federal-aid allotment, and without waiting for additional funds, the Michigan state highway department rushed to completion last fall a four-lane highway into the heart of Fort Custer, one of the larger army cantonments which lies just west of Battle Creek. The completed section lies entirely within the reservation, but provides access to the new camp by making a connection with existing roads to the east. Grading is now under way for an extension to highway connections on the west, which will be completed along with extensions east and south in 1941.*

WHEREVER new army camps, bases, training centers and war industry plants are under construction, the various state highway departments recognize the need for adequate access roads to serve these vital defense projects, but most are prevented by lack of funds or by legal restrictions from actually providing such roads. The Michigan state highway department, however, found ways to overcome all legal and financial obstacles and built a badly-needed four-lane highway into the heart of Fort Custer, just outside of Battle Creek, as a federal-aid project. The completed section, 2.3 miles long, lies entirely within the government reservation for the big camp, but another federal-aid project has been set up for extensions at both ends to supplement existing access roads. Right now grading is under way for an additional 1,900 ft. of four-lane road.

Fort Custer, an old World War camp, lies just west of the city limits of Battle Creek, south and east of the Kalamazoo River. Barracks are now being built for 20,000 men, and the reservation has been extended to about 16 sq. mi. For years, state route U.S. 12, leading west out of Battle Creek toward Kalamazoo, passed through the old camp grounds. The section within the camp was a narrow, high-crowned road, built in the old war days. A year or so ago, the state built a new route, U.S. 12, to the south of Battle Creek, connecting with the original route at Galesburg, and abandoned the old road into the army reservation as a state highway.

In order legally to build the new access road to and through Fort Custer, the state highway department had to reinstate the old road as a state and federal route. With the full cooperation of the Public Roads Administration the proposed new road (part rebuilding of the old route and part new location) was set up as a federal-aid project. A couple of federal-aid grade crossing projects, for which funds had been allotted, were lagging because of delay on the part of railroads involved, so these funds were switched to make possible construction of the camp highway.

Though the highway department started making plans and surveys in July, it was not until the middle of September that financial and legal questions were cleared up. Bids were opened on Sept. 25 for 2.3 miles of four-lane divided highway within the camp, and contract was awarded to Lewis & Frisinger, Ann Arbor, and E. B. Schwaderer, Cass City, for $219,000. By the end of the year the original project was completed and grading was started on the 1,900-ft. extension to the west, under an addition to the original contract.

Future plans

At present the completed section within the camp connects with Battle Creek streets and county roads to the east and through the old camp road to state route 96 to the west. It extends from the eastern boundary of the camp for 2.3 miles westward, little more than halfway across the reservation. The next project, now

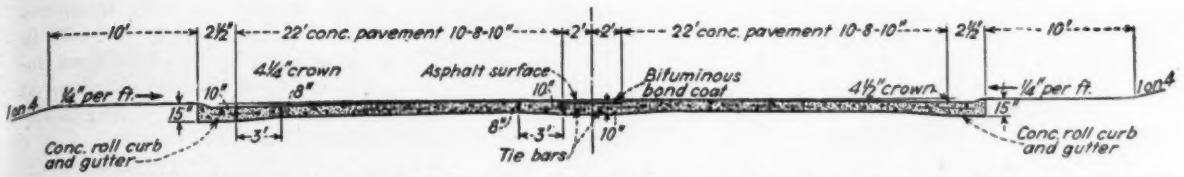


Fig. 2. Design of the four-lane highway features an asphalt-topped center strip and concrete roll curb and gutters. The gutters and concrete base for the center strip were poured after the roadway slabs had been completed.

set up, will continue the four-lane road for 2 miles westward to the town of Augusta. In this section will be an overpass crossing the main line of the Michigan Central R.R. and a new bridge over the Kalamazoo River. This arrangement is not perfect, for traffic will be dumped into the two-lane state route 96. The highway department is making plans, however, for widening route 96 between Augusta and Galesburg, where it meets the main east-west route U.S. 12, if and when traffic conditions warrant the improvement.

To the east, toward Battle Creek, a federal-aid project has been set up to extend the four-lane camp road for 1.3 miles on a new location, including an overpass over the Grand Trunk Western R.R., which lies in a shallow cut at the site of crossing. At the eastern end of this stretch, at the northeast corner of the Fort Custer airport, this extension meets a fairly good two-lane county road which runs 1.5 miles south to the new U.S. 12. This road provides access to the camp from the south. From the airport corner a new two-lane road will be built by the state eastward for 1.7 miles to the western city limits. Here traffic will have to filter through existing city streets.

Though not in the immediate program, the state will improve the county road connection from U.S. 12 if traffic conditions require it.

An incidental improvement that will relieve traffic congestion in the general vicinity of the camp is the addition of a third lane on U.S. 12 for five miles from Galesburg westward to Comstock, an improvement just being completed. The location of the original road, hemmed in on the north by the M.C.R.R. and on the south by highly improved property, forced the highway department to a three-lane compromise between the inadequate two-lane roadway and a very expensive four-lane widening. West of Comstock U.S. 12 divides into two routes into Kalamazoo. Eventually the state plans a new bypass for U.S. 12 to the south of Kalamazoo. All of these plans have a bearing on handling traffic, from and around Fort Custer.

Unusual design

The design of the four-lane pavement is rather unusual. It consists of two 22-ft. concrete slabs separated by a 4-ft. center strip of asphalt surface on a concrete base. The roadways are 10-8-10 in. thick. (Fig. 2)—10 in. thick at the outside and tapering to 8 in. in the outer 3 ft. of width. Along the outside edge of each roadway is a concrete gutter 30 in. wide, thickening to 15 in. for a roll curb at the outer edge. Concrete for the base of the 4-ft. center strip is 8 in. thick. Its bottom surface is flush with the bottom of the 10-in. edges of the adjacent roadway slabs, the top is depressed 2 in. below top of paving to receive the asphalt surfacing. Center strip and curbs are dowelled to the roadway slabs.

The asphalt surfaced center strip was adopted in place of the customary center curb or parkway because of the peculiar traffic condition on the road. This road is primarily for military service, and it will carry heavy movements of motorized equipment. The designers felt that because of the large amount of left turning on account of military maneuvers, and also because the road at times will be used full width in one direction, that the center strip should be useable as pavement. Yet a distinguishing dividing strip for normal two-way traffic was desired, which led to the adopted design.

Turnouts have been provided for all camp streets with 30-ft. radius intersections. The roll curbs are carried around the intersection curves. In general, 1-in. transverse expansion joints have been placed across the roadway and center strip slabs at in-

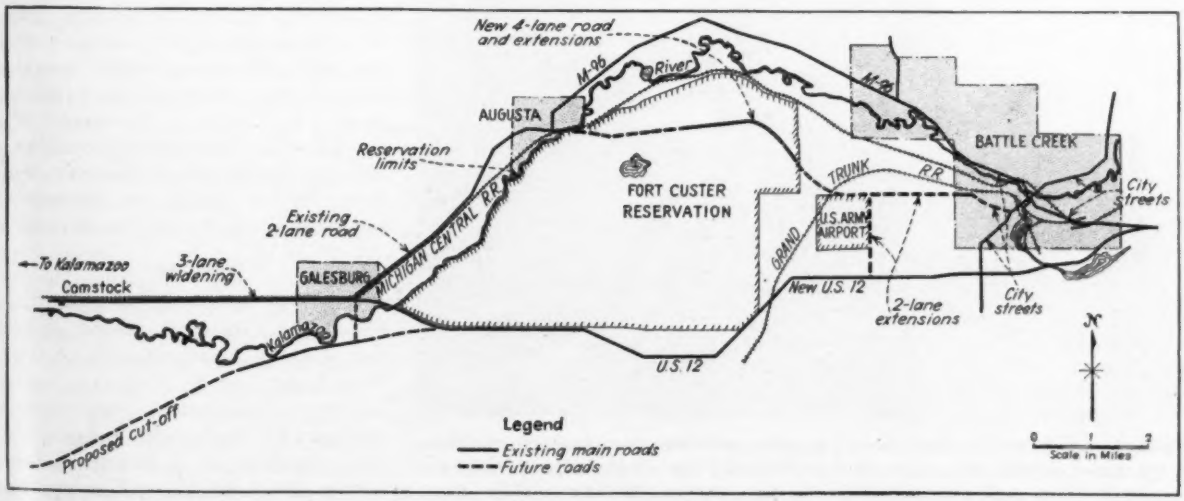


Fig. 3. Relation of the state-built access road through Fort Custer to existing roads in the vicinity of the reservation.

Fig. 4. Grading for the camp road was done with carrying scrapers, as shown in the upper picture. Below, a roller is preparing the subgrade base. Note the opening between slabs for the center strip base course. The lower picture shows the installation of the gutter and roll curb, which is poured with stiff concrete.

tervals of 120 ft. with transverse plane-of-weakness joints every 30 ft. Load transfer devices have been inserted at all expansion joints and at the plane-of-weakness joints midway between expansion joints.

Construction

Construction operations were carried out at a fast rate despite interference from camp building operations. The contractor set up a batching plant on a railroad spur within the camp, but before the job was half completed he was forced suddenly to move the plant, because of military requirements, to a location 1½ miles away.

Nearly 25,000 sq. yd. of old pavement had to be removed with rippers and scrapers. Grading was fairly light, 48,000 cu. yd., which was done with carrying scrapers. The subgrade was prepared by trimming and rolling, and each 22-ft. roadway was built separately, leaving the concrete for the center strip until both road slabs were complete. Then the 8-in. concrete base was poured between the slabs, and the asphalt surfacing placed after the base was primed with a bituminous bond coat.

Storm sewers, part of the road contract, were installed to provide complete drainage for the new highway. These involved 15,385 ft. of sewer pipe ranging from 10 to 24 in. in size. The sewer system required 83 catchbasins and 42 manholes. All of these sewers had to be built without interference with the camp sewer system, also under construction.

Military authorities were particular about damage to existing trees, many of which were newly planted, which caused the contractor some trouble in widening the old road and in building the sewers. Location of the road was also changed several times during design and plan stages because of changes in the camp layout, but once construction started the highway department successfully resisted further changes in alignment suggested by the military authorities.

Direction

Design of the project is under the direction of Harry C. Coons, chief engineer, Michigan State Highway Department, and W. H. Harvie, road engineer. Construction is being carried out by J. G. Schaub, engineer of field operations, E. E. Blomgren, district engineer and Wade Titus, project engineer.

Army convoys will put the roads of many states to severe tests during the coming year.

Roads in Maneuver Areas

***Contents in Brief**—Army maneuvers are going to increase greatly during 1941 and will continue at an accelerated rate for some years. Much of the movement will be over secondary roads not designed for such traffic. What may be expected to happen to these roads is shown by the experience of some of the states that had Army maneuvers last summer. Lack of adequate base course was found to be a major factor.*

MANEUVERS by units of the Regular Army and the federalized National Guard began late in 1940 and will increase in magnitude as those units are enlarged by the calling of more men into the service and as the regiments are supplied with new motorized equipment. Later this year, as the new army advances in its training and gets its field equipment, maneuvers will be multiplied. Thereafter, for an indefinite period, large-scale army maneuvers will become regular occurrences over a large part of this country. Here, in the making is a knotty problem for highway engineers and roadbuilders.

Experience with army maneuvers where they were held last year demonstrated that the higher types of road surfacing stand up well but that lightly surfaced roads are seriously damaged, principally under unfavorable weather conditions. Especially vulnerable are weak bases with surface treatment that does not exclude moisture from the base. Worthy of note is the fact that this damage developed during maneuvers by units having a relatively small amount of motorized equipment. Little yet is known as to the probable effect of much more complete mechanization, high-speed tanks and crawler-mounted field pieces.

Bridges and culverts on main roads were unharmed; serious injury to old bridges on secondary roads was avoided by limiting the loads put on them. Some old culverts were broken.

A deficiency common to all classes of roads except main roads of recent construction is lack of adequate shoulders where disabled equipment can be set out or where military convoys can stop clear of the traveled way to let other units or commercial traffic pass. What provision for building such wide shoulders should be made in future highway planning is one of the subjects now under consideration by officials of the War Department and the Public Roads Administration. Wide shoulders call for added rights-of-way on many secondary roads, which will add greatly to the cost of providing such shoulders should the work be undertaken on a large scale.

One school of thought in the Army is opposed to making any improvements in secondary roads to simplify army maneuvers, maintaining that an army must be trained to meet the worst conditions. But others hold that in regions where maneuvers are to be of common occurrence, some provision should be made so that normal traffic will not be seriously inconvenienced at frequent intervals.

Whether the standards of secondary roads that are to be used for maneuvers should be raised to cut down the cost of maintenance or whether the higher maintenance cost should be accepted as a matter of course is a question that no one has yet attempted to answer. Closely related is the question of who is to pay for the higher maintenance. To date, local bodies have accepted these costs as a patriotic duty, but that attitude cannot last indefinitely. Again, some army officers favor no raising of standards beyond those that come with normal improvements, holding that the army engineers gain valuable experience in strengthening culverts and bridges and in making emergency repairs to roads.

Normal traffic on main highways was not seriously hampered by the army maneuvers of last summer but that on secondary roads was delayed, due chiefly to narrow roadways. Military police, with the help of local police, were able to minimize the inconvenience, and generally did a good job of directing traffic.

Damage to Texas highways

Considerable damage was done to highways in Texas, according to E. J. Amey, administrative assistant of the Texas Highway Department, reporting for D. C. Greer, the new state highway engineer. The regular army held extensive maneuvers with its motorized divisions in the Sabine Forest area of east Texas last spring, approximately 70,000 men being engaged in the movements. With the exception of heavy commercial transports used to haul supplies, these army units had little motorized equipment, yet that equipment did considerable damage to the old and obsolete roads.

In estimating the damage suffered by the Texas highway system during the period of army maneuvers, each road was considered separately. Damage to the various roads ranged all the way from the loss of a little gravel surface to a very badly damaged base. Estimates of the cost of repairing these roads ran from $50 per mile up to $700 per mile, which latter amount was required to dig out the base failures and patch with additional gravel and seal these patches with cut-back asphalt and sweepings.

State Highway 21, from Nacogdoches to the Attoyac River, is a sample of the damage done to the lighter roads. This section is about 20 miles in length. Grading and drainage structures were built and a light iron-ore gravel surface, 16 ft. wide, was constructed in 1920. In 1936, an additional 25 cu.yd. of iron-ore gravel per station was added and the surface was sealed with cut-back asphalt at the rate of 0.9 gal. per sq.yd. using sweepings as cover material. From that time until the maneuvers took place the road received the normal amount of maintenance.

Due to the extraordinary maintenance required to restore this road to its former condition, a decision was made to scarify and maintain it as a gravel-surface road until such time as it can be rebuilt.

The maneuvers proved that the better type highways are adequate to take care of army traffic with its present equipment. They also showed very conclusively that the lighter types and older obsolete roads will not stand up under even the comparatively light motorized units to which some of them were subjected during maneuvers.

Little damage in New York

Highways of northern New York suffered little damage in the army maneuvers of last August, according to Arthur W. Brandt, superintendent of the Department of Public Works. This, however, was due in part to a combination of generally good roads in the areas used for maneuvering, good weather and little heavy equipment, empty ice trucks being used to represent tanks. Also, the roads over which equipment was moved were selected in advance, which, as Mr. Brandt points out, would not be possible in actual warfare when every road becomes a military road.

Speaking of the primary roads in New York State, Mr. Brandt says: "I do not think we need to worry much about our state highways not being able to withstand the heaviest army equipment except during the critical period in spring when frost is coming out of the ground. I am talking about the structural condition of the roads. We need wider roads, smoother roads, roads with wider shoulders, so that broken-down equipment can be brought over to the shoulders where it will not impede the remainder of the convoy. We need better sight conditions and other factors that tend to safer operation over highways. We also need bypasses around congested areas. We have enough work to do on our roads to place them in condition for army use in case of invasion, but it does not affect the structural end of the pavement as much as these other factors of highway construction." New York's main highways are in an especially favorable condition for handling heavy army equipment as the H-20 loading of the American Association of State Highway Officials has been used in all recent construction instead of the H-15 specified by the Army.

Lack of adequate shoulders that will permit military convoys to stop clear of the traveled way is one of the major handicaps to army maneuvers.

Light roads suffer in Wisconsin

Roads in Wisconsin having light surface treatment were the chief sufferers in the army maneuvers of last summer, according to E. L. Roettiger, state highway engineer. Field engineers of the highway commission observed the operations closely to determine the effect of military traffic on both the primary and secondary roads. A summary of their observations is given below. Mr. Roettiger notes that the findings cannot be taken as too conclusive due to the short period during which the maneuvers were in progress.

There was no noticeable effect on portland-cement concrete-paved structures. Bituminous surfaces, 1½ in. or more in thickness on reasonably adequate bases showed no noticeable

effects or distress under the military traffic. Light skin mats or surface treatments showed no noticeable effect when the aggregate mixed with the bituminous material was a good quality and when surfaces were 18 ft. or more in width and were supported by reasonably adequate bases.

Light surface treatments where the aggregate mixed with the bitumen was of local sand or subgrade soil of poor character, and where the width of the surface was relatively narrow with little or no pretense of a base course, did not stand up under the heavier traffic imposed by the maneuvers. Where failures occurred the specific cause for failure was lack of base course and poor aggregate and the low order of construction involved. The retreatment of such soil surfaces for purposes of alleviating dust and minimizing mud was accomplished at low cost.

Untreated gravel surfaces of township and county roads were not extensive in the maneuver area. On them there was considerable dusting and ordinary loss of aggregate due to more intensive traffic.

The natural-soil surfaces in the maneuver area did create somewhat of a problem, although the prevailing soil type is of relatively sandy nature. During the period of 30 days when such roads were used in connection with the maneuvers, there was almost continual rainy weather. Natural-soil surfaces did not stand up and became badly rutted, but their restoration was merely a matter of dragging and blading.

Many of the roads in the maneuver area were surfaced with natural shale which, under ordinary conditions, will produce a road surface equivalent to a good sand-clay surface. Shale surfaces that were in good condition prior to the maneuvers were worn considerably and in a few instances became quite chucky. The poor shale surfaces did not stand up and during the maneuvers they were reduced to about the same status as natural-soil roads.

Roadsides and shoulders on the primary route suffered no particular harm, and only a small amount of routine maintenance was required to bring them to their original condition. In cases where the shoulders were surfaced with aggregate or shale, they stood up in remarkably good shape. Naturally, during the wet weather that existed, the shoulders were rutted considerably, but were readily restored.

Characteristic types of damage to a gravel-surfaced road east of Nacogdoches, Tex., resulting from army maneuvers. The surfacing is 16 ft. wide, of iron-ore gravel sealed with cutback asphalt and covered with sweepings.

On state and county trunk highways there was no apparent damage to bridges and culverts. Some of the bridges on the county system were restricted to very low load limits. On county roads, several culverts were crushed or broken.

During the period of army maneuvers in Wisconsin, state and county highways were maintained with regular crews without any special effort to provide more intensive maintenance. Township roads enjoyed their regular maintenance, such as it was, and except in one or two instances no effort was made to increase the attention to such roads during the period of maneuvers. Army forces

from the Corps of Engineers hauled in some shale for the maintenance of shale roads and performed a certain amount of blade-grading work in maintaining the earth and shale type surfaces during the period that the maneuvers were in progress.

Mr. Roettiger states that from their observations the primary roads constructed to meet ordinary traffic requirements proved adequate for the military traffic. County trunk highways and township roads that were lightly surfaced for farm-to-market traffic did suffer some damage, but in all cases where there was a reasonable amount of shale or gravel surfacing protected with a bituminous surface treatment, the roads seemed to stand up in remarkably good shape. The principal deficiency that existed on local roads was that of width, and passenger vehicles were compelled to deviate from the narrow roadbed to the shoulders. The principal conclusion of the Wisconsin highway authorities is that most county trunk roads and township roads are too narrow to accommodate military traffic.

Maneuvers in Louisiana

Maneuvers were held in Louisiana from May 8 to 31 and again for a short time in August, 1940. Harry B. Henderlite, chief engineer of the Department of Highways, reports that the greatest damage to state roads was done to the asphalt surface treated highway between Zimmerman and Leesville, routes 107 and 21, over a total length of 44 miles. Of this, 14 miles was so deeply rutted by the heavy equipment as to require reconstruction, estimated to cost $4,000 per mile. The damaged road had a 6-in. gravel base with three applications of surface treatment. It had not been designed to withstand either the type or volume of traffic involved in the maneuvers. The remaining 30 miles was slightly damaged at many points.

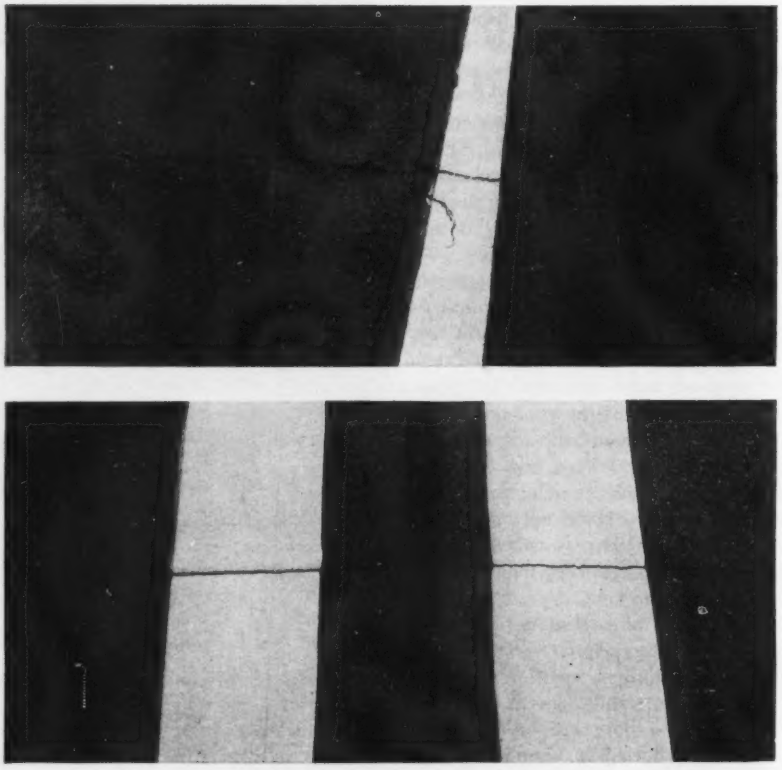
Damage to gravel roads was more extensive but not so serious; it was confined to Vernon Parish and the western section of Rapides Parish, where it was necessary to keep three extra tractors and blade graders at work, also eight trucks hauling local pit-run gravel, during the three weeks of the maneuvers in order to keep the roads from breaking up completely. This work cost $3,500, including equipment rentals. The Army Engineers left 300 men and some equipment in the maneuver area for several days at the close of the training period to get the roads back into shape. They did most of their work on parish roads but hauled 300 cu. yd. of gravel onto state roads and used three motor patrols to machine the surface. They also did minor patching on a few bridges, which left the bridges without damage.

J. N. Ball, Jr., district maintenance superintendent at Alexandria, estimates that gravel roads in areas that are to be used extensively for army maneuvers will have to be reinforced with 4 in. of additional surfacing material if they are to stand up.

Crack Control in Rhode Island

A METHOD for preventing irregular and ugly cracking of sheet asphalt pavement has been developed in Rhode Island. Immediately following laying of the surface course, and after the initial rolling has taken place, a chalk line is snapped on the pavement directly over the location of all transverse and longitudinal crack control plates, which had been installed previously in the concrete base course at relatively close intervals. A suitable cutting tool, heated to the proper temperature, then is used to cut the hot surfacing material to a depth of about 1 in. by carefully following the chalked line. Heavy manila paper of suitable weight and stiffness, about ¾-in. in depth and of suitable length is inserted in the freshly cut joint and the usual rolling operations are continued thereon. The results obtained by this method are clearly shown in the pictures reproduced below, one before and one after the new method was introduced.

This work is carried out under the direction of G. H. Henderson, deputy director and chief engineer, Rhode Island Division of Roads and Bridges.



Crack control in sheet asphalt pavement. The irregular cracking common to most sheet-asphalt pavement is shown in the upper picture; below is the result obtained in Rhode Island by inserting paper joints in the pavement as it is being rolled.

Expanding War Industries Cause Serious Traffic Problems

Contents in Brief—*Rapid expansion of industrial plants building military airplanes has resulted in serious congestion on streets and highways serving the plants. Similar conditions expected at expanding shipyards and other plants with war orders. Conditions at Los Angeles and Seattle are described and some of the steps proposed to relieve congestion are outlined.*

TRAFFIC CONGESTION at many airplane plants throughout the country already has become so serious as to cause intolerable delays, and yet most of the plants are being expanded and soon will add to their working forces. Similar conditions are expected to develop at other manufacturing plants engaged in filling war orders and at shipyards. How this traffic congestion is to be kept from seriously interfering with the defense program promises to be one of the major problems of many state highway engineers and city engineers during 1941.

So far no simple solutions have been put forward, but at Los Angeles, where the congestion around airplane plants is more serious than at any other point in the country, some remedial measures have been tried and others are proposed. Parking is a major element of the problem.

The problem is complicated by the fact that some plants where congestion is becoming serious are located on the outskirts of cities in the twilight zone between city and state control of traffic. A further complication that is expected to develop is in connection with the government's efforts to decentralize the defense operations by establishing new war industries at points remote from plants now working on defense orders. These changes will produce an entirely new traffic pattern on highways approaching the towns where the new industries are located, especially as the government will discourage migration from neighboring towns to the towns where the new plants are located, counting on workers in these towns driving to the plant for work each day.

Experience at Los Angeles, Seattle and a few other points where congestion already is serious indicates that street and highway widening projects that have been on the books for future work may have to be put under way in the immediate future.

Congestion in Los Angeles

Concentration in Los Angeles County of aircraft and other new factory operations incidental to the preparedness program, has brought new traffic problems to a community in which automobile registration totals one car for every 2.46 persons. The normal congestion that this high registration produces is further complicated by the fact that several airplane plants whose payrolls now exceed 15,000 are in locations where practically all workers have to come by automobile. Now that increases in many of these plants are in prospect, attention is being given to ways of relieving traffic congestion and facilitating the movement of workers to and from the plants. Separate parking areas for different shifts, staggered shift-change times and intermissions between successive shifts are some of the measures used to smooth out traffic peaks.

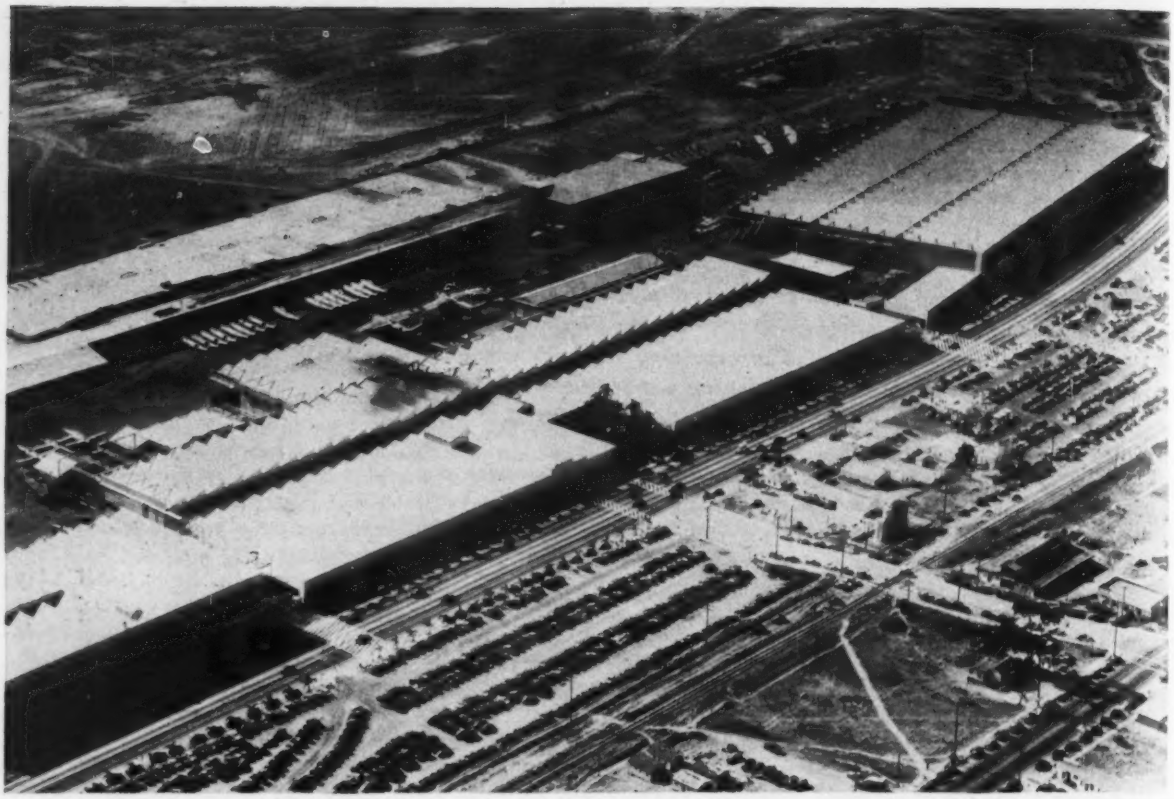
Factors that tend to smooth out the traffic peaks are: (a) the location of many of the plants away from areas where ordinary highway traffic is heavy; (b) timing the three-shift operations so that shift changes come at hours which are off-peak for the other traffic and (c) numerous boulevards and wide traffic arteries that lessen the tendency to concentrate traffic on a few routes. Several of the more important routes in the Los Angeles region which now are developed to only three-lane width are intended to be widened, ultimately, to six-lane routes. Hence, in that region, the industrial needs will only hasten the time when this improvement will be made.

To cite a typical case, two large airplane factories (North American Aviation, Inc., and the El Segundo division of the Douglas Aircraft Co.) located at Los Angeles Municipal Airport each employ about 15,000 persons. Prospects for expansion indicate that these payrolls will increase to about 25,000 early in 1941. This suggests the increase to 100-ft. width of Imperial Highway which is a distributing trunk serving five boulevards. Heretofore this widening has been delayed by the fact that parts of it lie in the cities of Los Angeles, El Segundo, Inglewood, Hawthorne and also in unincorporated area. Under the recent pressure for improved access to industrial plants, a joint committee has been formed to expedite the cooperation of the various communities in this arterial widening project.

Where new industrial areas are being laid out a common practice now is to obtain dedication of a 150-ft. right-of-way along airport frontage for development of two express roadways of three lanes each with a service road alongside. Each of these roadways will be separated by landscaped islands or dividing strips.

Looking still further to the future the "transit program for the Los Angeles metropolitan area", has proposed parkways that will serve the industrial districts with high-speed, grade-separated arteries leading to other sections of the city and metropolitan area.

Not all the large plants are in outlying districts: the Lockheed plant in the city of Burbank is in a location where heavy additions to ordinary highway traffic are sure to cause congestion. The rapid expansion of this plant in recent years, despite all palliative measures, has caused traffic obstruction for as long as 30 min. at the change-of-shift periods. Accordingly, plans recently have been com-



Only available parking lots at the Consolidated Aircraft plant at Los Angeles are across the Pacific Highway, making it necessary for employees to cross on foot. This picture was taken during working hours. The condition of the highway at a shift change is shown on the following page. Pedestrian crossings are clearly marked.

pleted for a grade-separation project near this plant which will pass the state highway under the tracks of the adjoining railroad and at the same time materially lessen interference of employee traffic with the other street traffic.

Parking areas needed

At some plants, even in locations where the traffic on the streets can be handled effectively, the parking problem has been serious. Extensive use of shoulders along the state highway near one airplane plant for parking employees' cars has become such a nuisance that the state highway officials have recommended that parking along this part of the state highway be prohibited altogether, thus making it incumbent upon the industry to furnish private parking areas for employees.

At the Santa Monica plant of the Douglas Aircraft Co. one side of the boulevard in front of the factory is utilized for parking cars of army and navy officials, company executives and those employees whose duties make it necessary for them to leave and enter the plant several times each day. Nearby parking lots are leased by the company to provide the larger part of parking area required. Should congestion tend to increase, the company is considering the adjustment of shifts to release employees in groups at 15-min. intervals. Additional police officers on traffic duty during peak periods are reported to have materially improved the movement of traffic.

At the El Segundo division of Douglas, two parking lots are available and are used by the three shifts in rotation. That is, when the third shift comes in, the lot last used by the first shift has been cleared and is available for shift three. When the next succeeding first shift comes on, the lot previously used by the second shift has been cleared and so on. Thus, by alternating the lot assigned to each shift, the traffic problem is materially simplified.

At the Consolidated Aircraft plant in San Diego the company owns two large parking lots immediately across the Pacific Highway from the plant. These lots have been graded, oiled, marked off and signed to facilitate the flow of traffic. Designated areas are reserved for executives and for visitors. Parking is under supervision of plant police. All cars are parked headed in the same direction, a no-left-turn rule is enforced and the direction of traffic is so controlled that there is minimum interference with movement to and from the other parking lot. Additional parking lot facilities are being provided as the plant expands.

When working hours at this plant were changed from three 8-hour shifts to two 10-hour shifts traffic peaks were made worse. However, by shifting the night employees to a slightly later start, the difficulty was cleared up in what plant executives refer to as an "amazing manner." Under the old plan the day crew went off at 5:30 p.m. and the night crew went on at 6:00 p.m. As now scheduled the day crew goes off at 5:30 as before but the night shift does not come on until 7:00 p.m., allowing an hour and a half for clearing traffic. Thus one shift is entirely clear of the neighborhood before the other one begins its

approach to the parking area.

At this plant employees must cross the highway to get from the parking lots to the plant. Thus, pedestrian and automotive peaks occur simultaneously. One overhead traffic signal at the main entrance is manually operated by the plant police for cross-traffic. State highway, city and plant officials are studying the question of separating pedestrian and automotive traffic.

Seattle has twofold problem

Expansion of the Boeing Airplane Co. plant at Seattle under the national defense program has caused a two-fold traffic problem which city, county and state officials, in cooperation with the plane company, are attempting to solve. The first and most unusual phase of this problem is the conflict between airplane and automobile traffic, which saw the city's main highway from the south blocked for a 10-min. period every other day while a 22-ton "Flying Fortress," with a wing spread of 104 ft., was towed by a tractor from Boeing's Plant No. 2 across the four-lane thoroughfare to King County's Boeing airfield. Although the crossings were carried out during periods of the day when traffic ordinarily is light, serious traffic tie-ups occurred. At present they present no problem because of a lag between contracts.

The second and more usual phase involves parking and the regulation of heavy traffic during the changing of shifts. During the past year, the Boeing payroll has been more than doubled to 7,500 men, divided among three shifts, while parking areas formerly available to employes are now occupied by plant additions. To the increased factory personnel also have been added 1,200 construction workers, also on three shifts. The adjacent highway and streets, as a result, are lined for miles with parked cars, creating a traffic hazard.

Both phases of the problem are expected to increase in severity after next March, when completion of additions totaling 1,068,000 sq. ft., now under construction will enable the plane company to increase its production to a reported four planes a day, with a payroll of 18,000 to 20,000 workers expected within a year.

Four proposed methods of separating the planes and the automobiles are under consideration. One involves simply the installation of traffic lights and gates, the latter to be lowered over the highway when a plane is ready to cross. Boeing officials believe that such precautions, plus the breaking of curbs and the improvement of yard conditions which will follow completion of the plant additions, will cut the plane-crossing time to three or four minutes. Two other proposals involve the diversion of traffic to other routes while the third calls for construction of a $600,000 underpass.

The state highway department, under the direction of James A. Davis, acting director, and R. W. Finke, bridge engineer, has submitted tentative plans to Oliver West, assistant to the president of the Boeing company, which call for a permanent grade-separation structure to care for all traffic entering or leaving the Boeing plant, as well as for the planes. Boeing officials are reported to object to a structure that must be used both by planes and automobiles. State engineers also have proposed to depress the highway to give a 14½-ft. clearance, with planes crossing to the field at the present highway level. If state and Boeing officials agree on the underpass as a solution, the state will seek federal funds for the project as a national defense measure. The structure would not be available for a year, however, with construction operations hindering both automobile and plane traffic in the interval.

Diversion of traffic from Pacific Highway could be accomplished either by the widening and extension of Airport Way, across Boeing Field from the Boeing plant, or by widening and extending West Marginal Way, across the Duwamish River from the plant. The first is the simpler of the two, with studies already conducted by County Engineer Harry H. Sisler and City Engineer Charles Wartelle. The West Marginal Way project, involving an expensive bridge, would require two years for completion but is considered of more long-range value.

First step toward solution of the parking problem was taken recently when King County rented an area on the west side of Boeing Field, across the highway from the Boeing plant, to The Austin Company, builders of the plant extensions, for $50 a month. This space accommodates 500 cars of Austin employees. When the additions have been completed, this area will be turned over to the Boeing company and enlarged to care for an estimated 5,000 cars.

County provides for parking

Indicative of the county's cooperative attitude was its rejection of a $20,000 bid from private interests which sought to buy a 14-acre county-owned tract near the plane plant for operation as a parking lot. The county declared it would reserve the property for lease at little or no cost to the Boeing company for parking. In addition, the King County planning commission, of which Joshua Vogel is executive engineer, is making a survey of other available parking areas in the vicinity.

The traffic problem also has been improved by the installation of new stop lights and the improvement of municipal transportation facilities to the area, the latter as an inducement to Boeing employes to ride the buses, trackless trolleys and street cars.

Cars crowd onto the Pacific Highway during a shift change at the Consolidated Aircraft plant and are held up to let other employees cross to the parking lot.

Division of Roads and Bridges

Fig. 1. Rhode Island builds new road on strategic network with outer lanes of concrete.

Concrete and Bituminous Macadam Used on Heavily Traveled Road

***Contents in Brief**—Rhode Island achieves economy with full utility when building first section of dual highway by paving outer lanes with concrete and inner lanes and shoulders with bituminous penetration macadam. Ultimate objective is addition of outer concrete lanes and conversion of center lane to wide median zone. Parallel construction operations result in real comparison of contract cost of concrete pavement and bituminous macadam.*

UNDER CONSTRUCTION in Rhode Island is the first stage of a dual highway on which concrete is used as paving for the heavily traveled lanes and bituminous macadam is laid on the less used center lanes and on the shoulders. This new construction is on Rhode Island Route 3, a shortcut from Westerly to Providence which saves nearly one-fourth of the distance and more in travel time as compared with old U. S. Route 1, the shore route along the Atlantic Ocean and Narragansett Bay. It is one of the main links in the strategic highway systems. The road is being improved gradually as funds become available, the worst bottlenecks being eliminated first.

Using concrete for the heavily traveled lanes and bituminous macadam for the center lanes not only results in considerable economy at no sacrifice of traffic capacity but also makes possible the future development of a dual highway by adding a second outer concrete lane on each side and by converting the macadamized center lanes into a wide median zone. The arrangement also has the advantage of permanent color marking for the roadway lanes.

The entire roadway is supported on a well prepared base designed to provide adequate drainage and permanent freedom from frost action.

The grading on the sections recently constructed was moderately heavy averaging 25,000 yd. to the mile with ledge rock accounting for about a fifth of the total. Excavation was handled generally by power shovel and wheeled hauling units. Fill slopes are made 1½ horizontal to 1 vertical and cut slopes 2 horizontal to 1 vertical. Grades are 7-percent maximum and curves are limited to about 3 deg.

Two typical sections of the pavement being laid are shown in Fig. 3. Where there is no median island, parallel stripes 3 ft. apart will be painted along the center line to separate opposing traffic. Curbs are all precast concrete with exposed surfaces bush-hammered. The median island curbs have reflector buttons set on the surface of the sloping face at 24-ft. centers.

Surface drainage is cared for through catchbasins at the edge of the slab or in the median strip with pipe discharge to a convenient point. Guard rails, where required, have

chestnut or cedar posts, 6-in.-dia., 5 ft. 4 in. long at 8-ft. centers set 3 ft. in the ground and supporting a 3x8-in. runner with top 18 in. above the ground surface.

Removal of concrete pavement

The work required removal and disposal of almost as many cubic yards of reinforced concrete pavement as were placed for the new work. This pavement, laid in 1923, and 1925, was 18 ft. wide with shoulders 5 ft. wide on each side. Its thickness was 8 in. reinforced with 65-lb. welded mesh, ½-in. U-bars in the corners at joints, ½-in. dowels through the center parting strip and ½-in. tierods. The old paving was broken with a truck-mounted, gasoline-engine powered, hoist operating a drop hammer which broke up the paving as the truck moved slowly ahead. A 1½-yd. diesel shovel was then able to load all the material which generally broke free of the steel. Pieces were broken small enough to permit use in the subgrade where the depth of preparation was 3 ft. or more.

Excellent base course

Following the procedure found most economical for New England conditions, the sub-base is given unusual attention. The entire width of roadway, including the shoulders, is excavated to a depth of at least 30 in. below the finished grade and a minimum 10-in. gravel course is placed which contains not less than 40 percent material larger than 1 in. with no pieces larger than ⅔ of the depth of the course. This is compacted with a 10-ton roller until there is no sinking or creeping ahead of the roller. Then a 12-in. layer of gravel is placed, in which not less than 30 per-

Fig. 2. Old pavement was broken with a blunt-nosed, 2,950-lb. drop hammer in fixed leads on the rear of a truck.

cent of the stones are larger than 1 in. and none larger than ⅔ of the depth. Rolling follows this, making an excellent sub-base for the paving work.

Concrete paving

Concrete lanes are laid first: on one section of the road they were completed late last fall, with the rest of the surfacing held over until spring. Concrete lanes are 11 ft. wide of 8-in. uniform thickness. The paving is reinforced 2 in. below the top with welded mesh, No. 3 wires longitudinally at 6 in. c. to c. and No. 6 wire transversely at 12 in. c. to c. Transverse joints are ¾ in. wide at 73-ft. 6-in. centers and filled with ¾x6-in. premoulded cork topped with 1½ in. of thermoplastic compound.

The moderate size of the jobs has permitted the use of hand labor for much of the subgrading and concrete handling. The base was covered with a layer of about 1 in. of sand and small gravel to form a cushion and prevent bonding with the base.

Concrete, 7 bags of cement to the yard, was mixed on the road by pavers serviced by trucks batched from bins set up at the nearby sand and gravel plants which supplied the aggregates. Cement was hauled by truck from rail delivery points to the batch bins. A double screed finisher followed the paver but vibration or longitudinal floats were not employed. A calcium chloride admixture, 2 lb. per bag of cement, was used in cold weather to facilitate early setting. Slump of the concrete ranged from 2 to 3 in., an easily workable mixture being secured which was finished with a minimum of surface manipulation. Steel reed brooms were drawn transversely across the green concrete to give a non-skid texture to the surface. Curing of the concrete was accomplished by heavy paper covers on one contract and by wet mats on another.

Bituminous macadam

The stone for the 5½-in. base for the bituminous macadam surface is 1 to 4-in. well graded material placed after the sub-base is entirely completed and rolled to exact shape. The stone is sprinkled if necessary to pro-

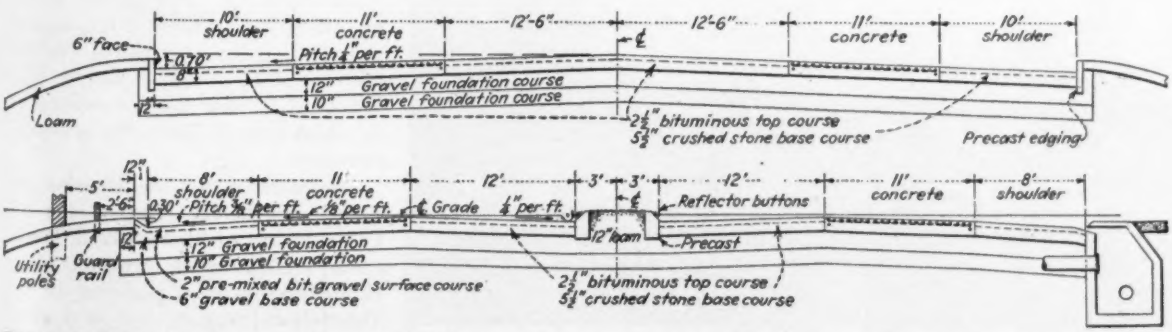
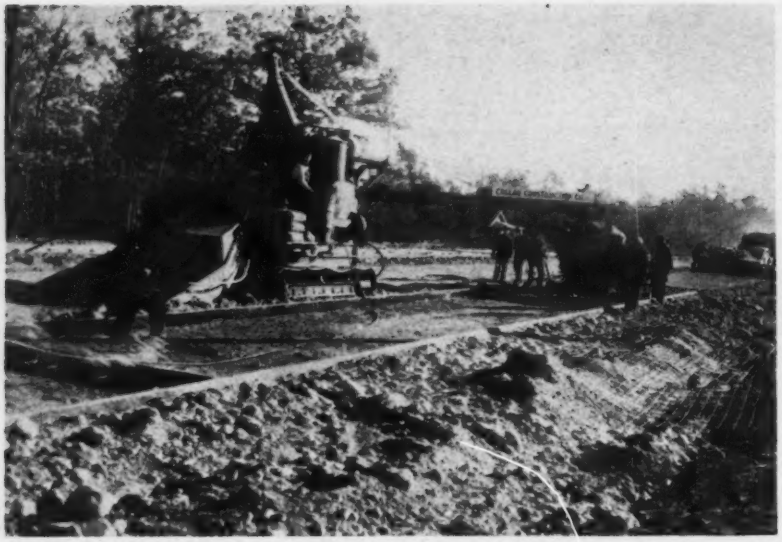


Fig. 3. Sections of two types of pavement being used in reconstruction of Route 3. Above is the roadway without a median strip on which separation is provided by two painted lines 3 ft. apart. The lower drawing shows a later design with a curbed median zone.



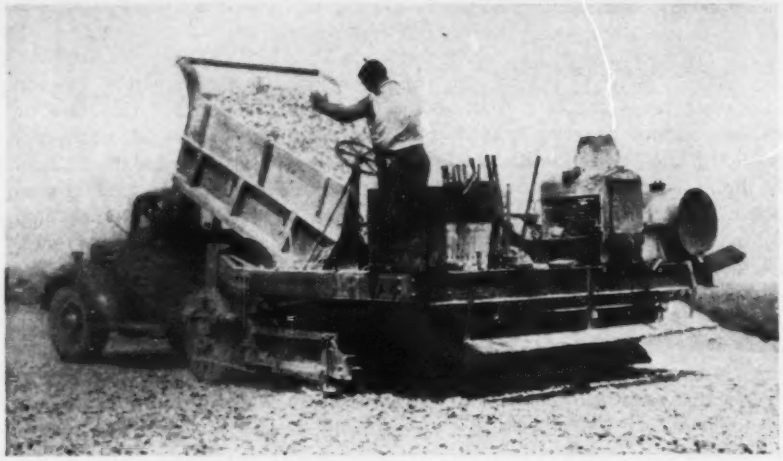


Fig. 4. Concrete was laid with paver (top picture) moving in the central lanes that were paved subsequently with bituminous macadam. The lower picture, shows a blacktop paver being used to spread stone for the penetration macadam, 1,000 tons being spread in a 9-hour day.

Fig. 5. Nooseneck Hill Road as widened under the reconstruction program. The new pavement consists of 10-ft. paved shoulders, two 11-ft. concrete lanes and 25-ft. bituminous macadam to be separated into two lanes by painted stripes.

vide the moisture necessary for best compaction under a three-wheel, 10-ton roller.

The one course wearing surface is 90 percent 1¼-in. to 2¼-in. stone placed by a mechanical spreader, and rolled by the 10-ton roller for not less than one hour per 150 sq.yd. of surface. This was followed by a 1¾-gal. per sq.yd. application of bituminous binder at about 350 deg. F. spread with a bituminous distributor. Next, filler stone, 85 percent ½ to ¾ in., was uniformly placed over the entire surface and rolled in to secure thorough bonding in the bituminous material. Then about ¾ gal. per sq.yd. of 90 to 100 penetration asphalt was added by the bituminous distributor, as shown in Fig. 1, and covered with stone chips, 80 percent ¼ to ½-in. size spread by hand. Rolling then brings the surface to final grade and full compaction.

Assuming that the bids were not substantially unbalanced the use of three types of paving on the same contract gives an opportunity for comparison of costs. Eight-inch reinforced-concrete pavement cost $1.83 per sq.yd.; 2½-in. bituminous macadam on 5½-in. base, $0.97 per sq.yd.; and 2-in. pre-mixed bituminous gravel surface course with 6-in. gravel base, $0.33 per sq.yd. Gravel base has cost $0.37 cu.yd. in place and earth excavation $0.24 per cu.yd.

Average contract bid cost for paving work in Rhode Island for the six-year period 1934 to 1939 inclusive has been: bituminous paving on concrete base $2.24 per sq.yd.; reinforced cement concrete $1.96 per sq. yd.; bituminous macadam, including base, $1.13 per sq.yd.; gravel foundation $0.51 per cu.yd.; and earth excavation $0.35 per cu.yd.

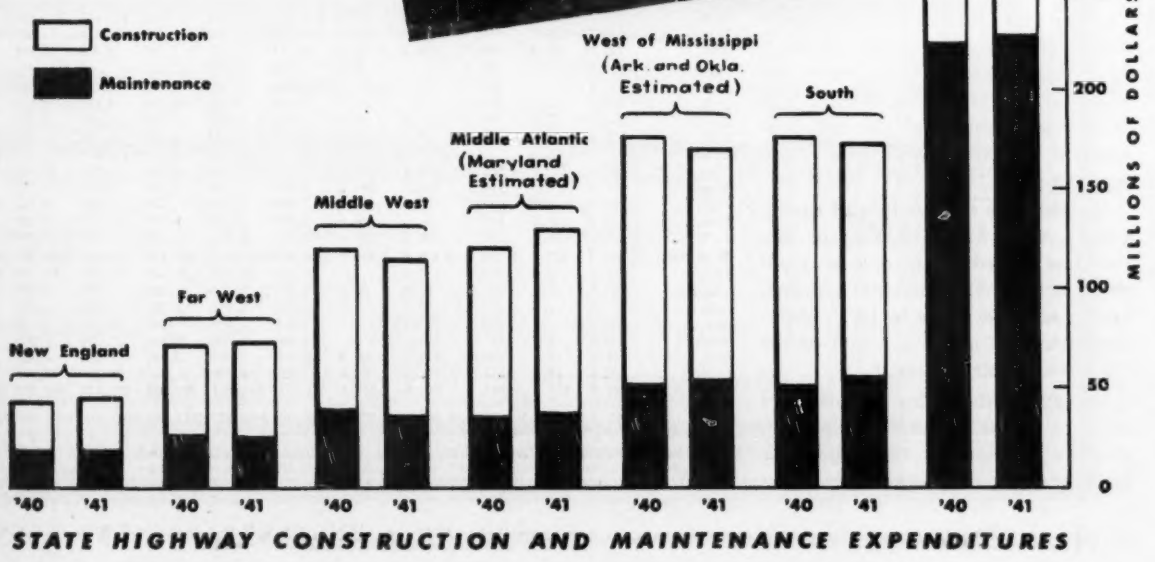
The work described is on a 3.8-mile ($288,169) contract of M. A. Gammino Const. Co., Providence, R. I., on which J. F. Ableman was superintendent, and on a 1.6-mile ($134,658) contract of Callan Const. Co., Bristol, R. I., now under construction on which John B. Foley, Jr., is superintendent.

The work is for the Division of Roads and Bridges, Department of Public Works of Rhode Island, Frederick V. Waterman, director, Geo. H. Henderson, chief engineer, H. C. Thierfelder, deputy chief and construction engineer. H. R. Davis is in charge in the field on the two contracts as resident engineer.

Highway and railway approaches to the Baton Rouge Bridge in Louisiana.

Road Building

1940 Accomplishments
1941 Budgets and Outlook



STATE HIGHWAY CONSTRUCTION AND MAINTENANCE EXPENDITURES

What the Figures Show

***Contents in Brief**—In 1940, 46 of the 48 states built 33,128 miles of all types of roads with their $452,902,000 in new construction money. This mileage is an 11 per cent gain in the face of a drop of 1.5 per cent in construction money spent. Budgets for 1941 for 45 states indicate a slight increase in expenditures, with construction about even, and maintenance and equipment up 1 per cent.*

EARLY ESTIMATES OF 1940 construction and maintenance expenditures from 46 of the 48 state highway departments total $667,295,000, a decline of 2.5 per cent from the $685,084,000 reported for the same states in 1939. At the beginning of 1940 budget data gathered from the highway departments indicated that 1940 expenditures would outstrip 1939 by 6 per cent. Hesitancy of the departments, however, to embark on large programs in the latter part of 1940 in view of the uncertainties of defense highway needs, probably had the effect of tightening the purse strings for the time being, and the result was a decrease in 1940 expenditures instead of the predicted gain.

Construction's share of the 46-state expenditure volume, $452,902,000, is 1.5 per cent lower than a year ago, and is 68 per cent of the 1940 total. Of the 1940 construction funds, the eleven Southern states spent $120,737,000, or 26.7 per cent; thirteen of the fourteen West of Mississippi states (Oklahoma missing) expended $113,177,000, 25.0 per cent; the five Middle West states, $80,322,000, or 17.7 per cent; four of the five Middle Atlantic states (Maryland missing), $69,151,000, or 15.3 per cent; the seven Far Western states, $44,373,000, or 9.8 per cent; and the six New England States, $25,142,000, or 5.5 per cent.

Maintenance and equipment expenditures total $214,393,000 for the year just passed, a decrease of 5 per cent from the $225,582,000 reported for the same 46 states in 1939. Maintenance makes up 32 per cent of the 1940 preliminary estimate.

The expenditures for maintenance and equipment in each of the geographical sections of the nation for 1940, and the per cent U. S. maintenance spending are: South, $49,014,000, or 22.8 per cent; West of Mississippi, $46,838,000, or 21.8 per cent; Middle West, $40,639,000, or 19.0 per cent; Middle Atlantic, $31,813,000, or 14.9 per cent; Far West, $27,061,000, or 12.6 per cent; and New England, $19,028,000, or 8.9 per cent.

The ratio of maintenance spending to that of the total for maintenance and construction combined again finds the highest percentage in the New England states, 43 per cent; Far West is next with 38 per cent; Middle

HIGHWAY CONSTRUCTION RECORDS FOR 46 STATES

States	Mileage Completed — 1940					Expenditures — 1940 (,000 omitted)			Expenditure Budget — 1941 (,000 omitted)		
	Total	Pavement	Dust-less	Non-Dust-less	Graded & Drained	Const. & Maint Total	Con. struc-tion	Maint. & Equip-ment	Total Const. & Maint.	Con-struc-tion	Maint. & Equip-ment
Me.	333.0	16.0	274.0	43.0	.....	$9,433	$5,200	$4,233	$9,560	$5,500	$4,060
N. H.	121.0	11.0	80.0	30.0	.....	5,825	2,603	3,222	5,311	1,911	3,400
Vt.	146.5	18.5	128.0	.....	.....	4,737	2,925	1,812	4,737	2,925	1,812
Mass.	36.0	31.0	5.0	.....	.....	7,079	1,781	5,298	7,079[1]	1,781[1]	5,298
R. I.	15.4	15.0	0.4	.....	.....	3,555	2,400	1,155	3,925	2,600	1,325
Conn.	69.1	47.0	10.7	.....	11.4	13,541	10,233	3,308	14,541	11,233	3,308
New Eng.	**721.0**	**138.5**	**498.1**	**73.0**	**11.4**	**$44,170**	**$25,142**	**$19,028**	**$45,153**	**$25,950**	**$19,203**
N. Y.	263.5	207.5*	20.0*	20.0*	16.0*	$28,049	$18,849	$9,200	$28,500	$18,500	$10,000
N. J.	57.7	29.3	.....	0.8	27.6	14,584	10,974	3,610	18,500[1]	15,000[1]	3,500[1]
Pa.	2,150.0	400.0	1,750.0[2]	.....	.....	58,000	38,000	18,000	59,500	40,000	19,500
Md.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Del.	66.8	27.8	13.8	0.6	24.6	2,331	1,328[3]	1,003	2,560	1,500	1,060
Mid. Atl.	**2,538.0**	**664.6**	**1,783.8**	**21.4**	**68.2**	**$100,964**	**$69,151**	**$31,813**	**$109,060**	**$75,000**	**$34,060**
Va.	431.7	220.0[4]	155.2[4]	20.8	35.7	$15,686	$12,799	$2,887	$17,936	$15,076	$2,860
W. Va.	968.3	103.2	601.6	172.0	91.5	11,754	6,154	5,600	15,126	9,526	5,600
N. C.	628.0	286.0	280.0	.....	62.0	23,490	10,290	13,200	25,900	9,700	16,200
S. C.	282.0	9.1	161.9	.....	111.0	11,307	7,950	3,357	11,307	7,950	3,357
Ga.	3,232.0	125.0	1,478.0	870.0	759.0	19,966	15,573	4,393	17,000	15,000	2,000
Fla.	.....	.....	.....	.....	.....	21,603	17,437	4,166	20,000	14,000	6,000
Ala.	1,568.0	10.0	836.0	85.0	647.0	12,952	9,321	3,631	11,300	8,500	2,800
Miss.	842.7	157.5	189.6	11.2	484.4	17,888	15,632	2,256	4,188	2,313	1,875
La.	291.0	40.0	19.0	173.0	59.0	11,119	9,920	1,199	22,032	18,282	3,750
Ky.	558.0	181.0	192.0	.....	185.0	16,925	11,000	5,925	16,400	10,000	6,400
Tenn.	105.3	28.1	24.9	20.3	32.0	7,061	4,661	2,400	12,026	9,626	2,400
South	**8,907.0**	**1,159.9**	**3,928.2**	**1,352.3**	**2,466.6**	**$169,751**	**$120,737**	**$49,014**	**$173,215**	**$119,973**	**$53,242**
Ohio	3,114.0	424.0[5]	2,678.0[5]	10.0	2.0	$44,565	$26,165	$18,400	$39,500	$24,000	$15,500
Ind.	647.0	171.0	140.0	137.0	199.0	16,896	12,357	4,539	20,911	16,411	4,500
Ill.	409.0	167.0	112.0	86.0	104.0	27,350	19,800	7,550	27,500	20,000	7,500
Wis.	355.0	50.0	107.0	86.0	112.0	9,500	6,500	3,000	9,500[1]	6,500[1]	3,000
Mich.	1,462.0	287.0	904.0	224.0	77.0	22,650	15,500	7,150	18,494	11,779	6,715
Mid. West	**6,047.0**	**1,099.0**	**3,941.0**	**543.0**	**494.0**	**$120,961**	**$80,322**	**$40,639**	**$115,905**	**$78,690**	**$37,215**
Minn.	1,096.0	57.0	289.0	314.0	436.0	$17,270	$10,634	$6,636	$20,773	$12,899	$7,874
Iowa	1,398.7	171.8	18.2	473.9	734.8	15,707	11,639	4,068	15,000	11,000	4,000
Mo.	733.0	164.4	244.7	234.5	99.4	19,181	13,581	5,600	16,260	10,660	5,600
Ark.	168.0	15.0	125.0	.....	28.0	7,144	3,799	3,345[1]	.....	.....	.....
N. D.	178.0	.....	178.0	.....	.....	4,260	2,752	1,508	4,675	2,950	1,725
S. D.	635.9	11.6	236.6	81.1	306.6	6,655	4,265	2,390	6,000	4,000	2,000
Neb.	854.0	17.0	606.0	184.0	47.0	11,680	9,000	2,680	8,665	5,665	3,000
Kan.	875.8	24.3	528.8	152.9	169.8	13,252	8,822	4,430	12,210	7,630	4,580
Okla.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Tex.	2,626.0	126.0	1,302.0	682.0	516.0	37,747	27,725	10,022	36,500[1]	26,700[1]	9,800[1]
Mont.	865.0	.....	194.0	380.0	291.0	8,404	6,260	2,144	7,900	5,700	2,200
Wyo.	438.8	.....	371.9	11.5	55.4	5,050	4,300	750	4,450	3,700	750
Colo.	658.5	14.5	529.0	.....	115.0	6,900	5,400	1,500	7,000	5,500	1,500
N. M.	1,102.0	26.0	520.0	336.0	220.0[6]	6,765	5,000	1,765	7,750	6,000	1,750
W. of Miss.	**11,629.7**	**627.6**	**5,143.2**	**2,839.9**	**3,019.0**	**$160,015**	**$113,177**	**$46,838**	**$147,183**	**$102,404**	**$44,779**
Idaho	349.3	0.6	235.3	113.4	.....	$4,650	$3,110	$1,540	$5,338	$3,638	$1,700
Utah	330.0	17.0	193.0	87.0	33.0	4,350	2,900	1,450	4,400	3,000	1,400
Ariz.	231.6	7.8	209.4	5.8	8.6	7,443	5,048	2,395	7,203	4,478	2,725
Nev.	222.3	.....	188.8	33.5	.....	3,414	2,565	849	3,367	2,417	950
Wash.	528.0	8.0	357.0	163.0	.....	12,900	7,500	5,400	11,700	7,000	4,700
Ore.	915.0	77.0	394.0	279.0	165.0	10,780	6,800	3,980	11,980	7,750	4,230
Calif.	708.8	46.8	323.6	281.8	56.6	27,897	16,450	11,447	28,550[1]	19,000[1]	9,550[1]
Far West	**3,285.0**	**157.2**	**1,901.1**	**963.5**	**263.2**	**$71,434**	**$44,373**	**$27,061**	**$72,538**	**$47,283**	**$25,255**
U. S.	**33,127.7**	**3,816.8**	**17,195.4**	**5,793.1**	**6,322.4**	**$667,295**	**$452,902**	**$214,393**	**$663,054**	**$449,300**	**$213,754**

[1] Unofficial estimate. [2] Includes 450 mi. widening — bituminous materials. [3] Includes bridges and grade crossing elimination. [4] Includes widening. [5] 473 mi. maintenance-financed WPA projects of various types included. [6] Includes 150 miles of miscellaneous improvements. * Estimated.

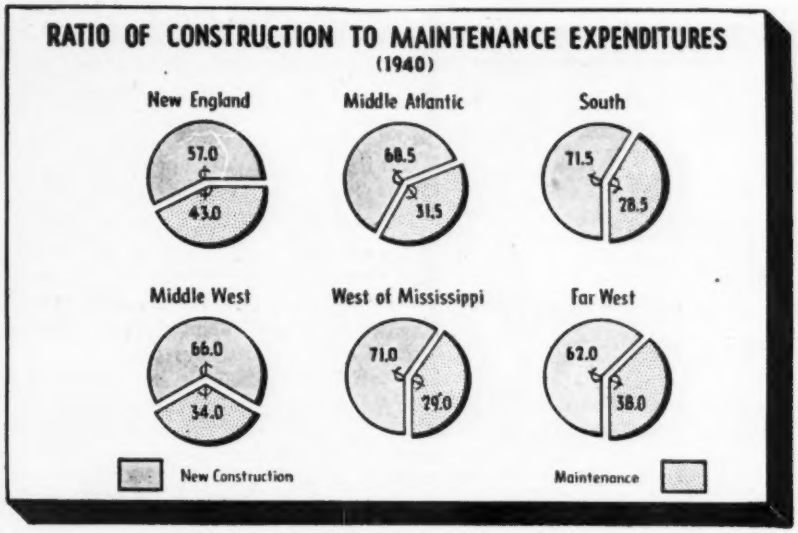
West, 33.6 per cent; followed by the Middle Atlantic states with 31.5 per cent, at the same level as the construction-maintenance ratio for the nation as a whole. Ratios for states west of the Mississippi, 29 per cent, and the Southern states, 29 per cent, are below the national average.

The 1940 maintenance ratio for the United States, 32 per cent, has fallen below the 32.4 per cent in 1939, and 33 per cent in 1938, but remains well above the 27 per cent and 29 per cent ratios credited respectively to 1936 and 1937.

Reducing these millions of dollars in highway expenditures to a per capita basis brings out the fact that each person in the country (according to the 1940 census) spent on an average of $3.59 for new state highway construction, and $1.70 for maintenance, or a total of $5.29.

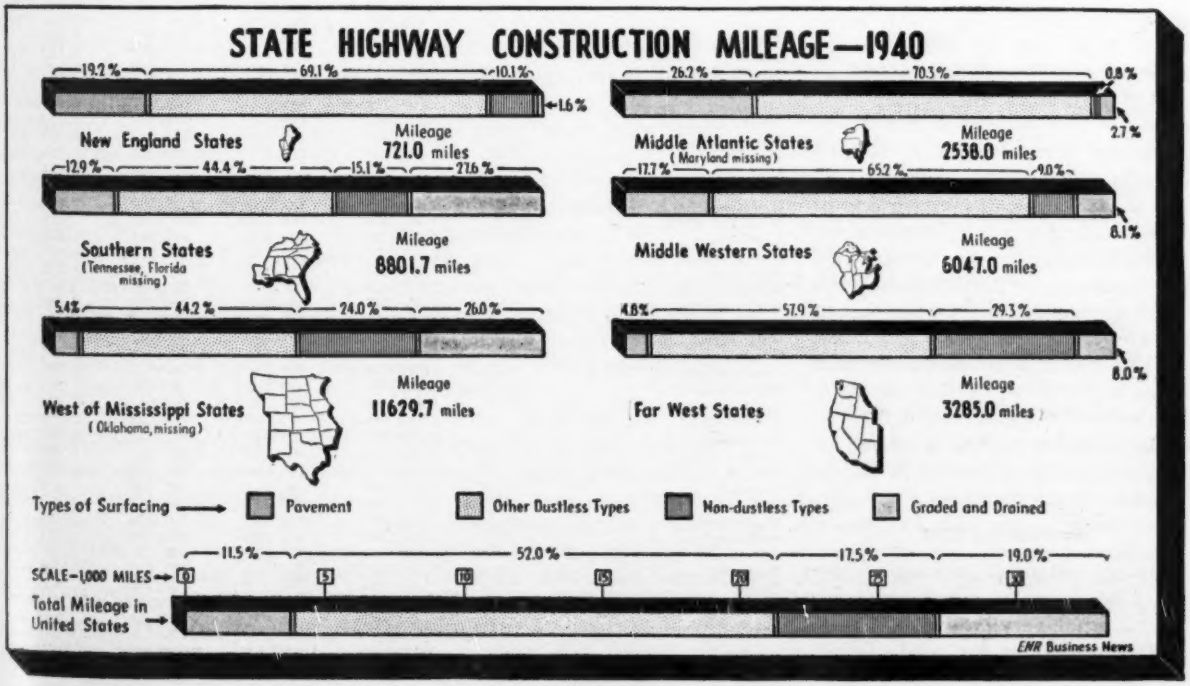
Per capita spending in the South and West are higher than the national average as is to be expected, and as has been the case in the last few years. West of Mississippi states report the highest per capita expenditure, $6.60, followed by Far West, $6.25; South, $6.00; New England, $5.24; Middle West, $4.54; and Middle Atlantic, $3.54.

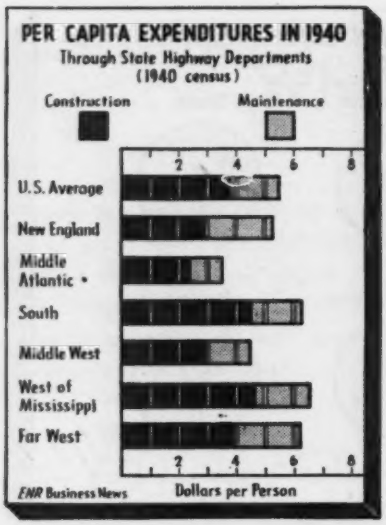
For construction alone, West of Mississippi is highest, $4.67 per person; then South, $4.27; Far West, $3.88; Middle West, $3.01; New England, $2.98; and Middle Atlantic, $2.42. A glance at maintenance statistics finds Far West highest with $2.37 per capita; followed by New England, $2.26; West of Mississippi, $1.93; South, $1.73; Middle West, $1.53; and Middle Atlantic, $1.12.



Types of surfacing

The 33,128 miles of roads built in 1940 is an 11 per cent gain over the 1939 mileage for same 45 states. By type of construction, 17,195 miles, or 52 per cent of the total is "dustless", including plant-mix without precise control, road mix, and bituminous surface-treated gravel or stone surfacing. "Pavement" of concrete, brick, stone, wood and asphalt block, sheet asphalt, rock asphalt, bituminous concrete or bituminous penetration, which is of high-type construction, is responsible for 3,817 miles, or 11.5 per cent of the year's total. "Non-dustless" surfaces, which include plain macadam, gravel, traffic-bound crushed stone, slag, chert, caliche, iron ore, chats, sand-clay and topsoil surfacings, total 5,793 miles, and are 17.5 per cent of the mileage. The balance of the 1940 total, 6,322 miles, is the "graded and drained" type of roadway, and is 19.0 per cent of the total improved mileage. These classifications of "pavement", "dust-





The 1941 budget total, $663,054,000, compares with the 45-state total of $660,151,000 for last year, an increase of 0.4 per cent. In the face of the cut in federal aid funds for the fiscal year 1942, the budgeted figures for the current year are very encouraging. Add to this the fact that construction of access roads to camps and cantonments, and improvement to existing highways and bridges of strategic military value are not provided for adequately, and the outlook for 1941 becomes brighter.

In 1941 the 45 states (Maryland, Arkansas and Oklahoma missing) expect to spend $449,300,000 of their budgeted $663,054,000 for new construction, an increase of about $200,000 over 1940, and $213,754,000 for maintenance and equipment, an increase of 1 per cent over the $211,048,000 spent in these states in 1940.

The Middle Atlantic states are planning an 8 per cent increase in their total expenditures over 1940. New England and Southern budgets are each up 2 per cent, and Far West is up 1.5 per cent. Middle West and West of Mississippi planned expenditures for 1941 are 4 per cent lower than in 1940.

less", "non-dustless", and "graded and drained" are those now used by the Public Roads Administration and are used in *ENR* for the first time.

A geographical analysis of the high-type "pavement" mileage shows that the South constructed 1,160 miles of this type of road during the year, 13.0 per cent of its mileage total. Middle West built 1,069 miles, 17.7 per cent of its total; Middle Atlantic states, 665 miles, 26.2 per cent; West of Mississippi, 627 miles, 5.4 per cent; Far West, 157 miles, 4.8 per cent; and New England, 138 miles, or 19.2 per cent of its mileage total.

"Dustless" type surfacing was the selection of West of Mississippi states for 5,143 miles, or 44.2 per cent of its improvements; for 3,941 miles, or 65.2 per cent of Middle West's total; for 3,928 miles, or 44.1 per cent of the South's mileage; for 1,901 miles, or 57.9 per cent of Far West's surfacing; for 1,784 miles, or 70.3 per cent of Middle Atlantic's mileage; and for 498 miles, or 69.1 per cent of New England's road improvement.

"Non-dustless" road construction was the choice for 2,840 miles in West of Mississippi states, 24.4 per cent of the area's total mileage; 1,352 miles, or 15.2 per cent in the South; 964 miles in Far West, or 29.3 per cent; 543 miles in Middle West, or 9.0 per cent; 73 miles in New England, or 10.1 per cent; and 21 miles in Middle Atlantic, or 0.8 per cent.

Outlook for 1941

Budget estimates available from 45 state highway departments for 1941 indicate very little change from 1940 expenditures for roadbuilding.

Federal Highway Funds Alloted

APPORTIONMENT of $134,062,500 among the 48 states for work on the federal-aid highway systems and for grade-crossing elimination was announced on Dec. 30 by John M. Carmody, Federal Works Administrator. These funds are the major part of $137,500,000 authorized by Congress in an act passed Sept. 5, 1940, and are for the fiscal year beginning July 1, 1941. The balance is for administrative expenses and special work carried out by the Public Roads Administration.

APPORTIONMENT OF HIGHWAY FUNDS FOR THE FISCAL YEAR 1942

State	Regular Federal Aid	Secondary or Feeder Roads	Grade Crossings	Total
Alabama	$2,080,245	$364,043	$406,480	$2,850,768
Arizona	1,435,382	251,192	129,679	1,816,253
Arkansas	1,707,928	298,887	336,619	2,343,434
California	3,982,125	696,872	799,099	5,478,096
Colorado	1,798,524	314,742	252,705	2,365,971
Connecticut	620,997	108,674	164,330	894,001
Delaware	487,500	85,313	97,500	670,313
Florida	1,425,748	249,506	299,547	1,974,801
Georgia	2,519,366	440,889	488,535	3,448,790
Idaho	1,235,985	216,297	167,025	1,619,307
Illinois	3,954,419	692,023	1,011,900	5,658,342
Indiana	2,415,900	422,782	501,817	3,340,499
Iowa	2,505,523	438,467	538,808	3,482,798
Kansas	2,539,360	444,388	487,825	3,471,573
Kentucky	1,840,894	322,156	357,973	2,521,023
Louisiana	1,467,188	256,758	318,101	2,042,047
Maine	866,500	151,637	133,657	1,151,794
Maryland	833,715	145,900	204,759	1,184,374
Massachusetts	1,311,369	229,489	387,602	1,928,460
Michigan	3,028,316	529,955	651,077	4,209,348
Minnesota	2,709,402	474,145	525,569	3,709,116
Mississippi	1,773,232	310,316	314,017	2,397,565
Missouri	2,967,206	519,261	580,174	4,066,641
Montana	2,018,907	353,309	262,484	2,634,700
Nebraska	1,991,356	348,487	335,670	2,675,513
Nevada	1,274,718	223,076	97,500	1,595,294
New Hampshire	487,500	85,313	97,500	670,313
New Jersey	1,274,429	223,025	376,651	1,874,105
New Mexico	1,620,981	283,672	170,673	2,075,326
New York	4,824,597	844,304	1,330,049	6,998,950
North Carolina	2,378,838	416,297	515,538	3,310,673
North Dakota	1,504,377	263,266	300,388	2,068,031
Ohio	3,526,165	617,079	818,286	4,961,533
Oklahoma	2,271,217	397,463	439,081	3,107,761
Oregon	1,647,906	288,383	228,715	2,165,004
Pennsylvania	4,095,568	716,724	1,091,120	5,903,412
Rhode Island	487,500	85,313	97,500	670,313
South Carolina	1,341,640	234,787	297,944	1,874,371
South Dakota	1,583,613	277,132	260,078	2,120,823
Tennessee	2,114,507	370,039	381,156	2,865,702
Texas	6,294,440	1,101,527	1,096,857	8,492,824
Utah	1,123,714	196,650	129,466	1,449,830
Vermont	487,500	85,313	97,500	670,313
Virginia	1,844,069	322,712	375,157	2,541,938
Washington	1,580,939	276,664	304,376	2,161,979
West Virginia	1,095,332	191,683	264,524	1,551,539
Wisconsin	2,406,404	421,121	484,129	3,311,654
Wyoming	1,246,353	218,112	131,610	1,596,075
Hawaii	487,500	85,313	97,500	670,313
District of Columbia	487,500	85,313	97,500	670,313
Puerto Rico	495,603	86,731	166,250	748,584
Total	$97,500,000	$17,062,500	$19,500,000	$134,062,500

Relocation between Keystone and Ely, Nevada, to eliminate two bad curves and an obsolete overpass.

Highway Expenditures and Plans

***Contents in Brief**—Expenditures of the individual states during 1940 are given together with anticipated expenditures in 1941. Also given is the mileage of all major classes of roads built by state highway departments in 1940 and a brief summary of significant trends in highway work in each state. The effect of military road work on 1941 plans also is stated.*

GIVEN in the following pages is a terse summary of road operations in each state of the Union in 1940 and the amounts of money that each state expects to spend on construction and maintenance in 1941. Accompanying this statistical information are short statements of significant trends or major plans of each state highway department.

Worthy of note in these statements is the increasing emphasis on safety, especially in building safety into the highway itself. Thus New Hampshire, with limited funds to spend, is concentrating them on eliminating bad curves or steep grades on its main traveled routes or in building bypasses around old towns whose crooked, narrow streets create dangerous bottlenecks. Illinois is channelizing traffic at major intersections.

Practical applications of soil mechanics also are widely reported. The lessons learned in laboratories are being applied in the field with the result that stronger base courses are laid at no increased cost, surfacing mixtures are better graded and hence made more stable, and proportioning methods are being developed that permit wider use of local materials. All this cuts costs and adds to the quality of the finished product.

Costs also are being cut by wider mechanization; use of modern grading equipment reduces the unit cost of moving earth, and this in return permits the highway engineers to design better roads at no increase in first cost and with a material saving in maintenance.

Shoulder widening is reported from many states and much greater attention is being given to the material going into shoulders. Some states are getting greater stability by proper selection and grading of materials while others are stabilizing shoulders with bituminous materials or cement.

Base stabilization with cement or bituminous oils is reported as on the increase. In a few states test sections of road have been built to get comparative results by using different methods for base construction and surface treatment. Especially notable is the work being done in Kansas to correlate climate and soils in the design of surfaces for low-grade roads.

In every state the road plans for 1941 are going to be affected by national defense requirements. Just what these requirements are to be still is largely unknown, but where state highway departments have made any plans to adjust their operations to the needs of the War Department, their plans are given in the statements that follow.

New England States

Maine plans bridge rebuilding

A major problem of the State Highway Commission of Maine, according to Lucius D. Barrows, chief engineer, is the reconstruction of some of the old highway bridges of the state. Reconstruction is needed for normal requirements and will serve for the strategic network.

Some of the projects in Maine that

are scheduled for construction in 1941 are on the strategic network, and it is expected that by 1942 highway expenditures will be limited to such roads.

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	16
Other Dustless Surface	274
Non-Dustless Surface	43
Graded and Drained	....
Total	333

EXPENDITURES	1940	Estimated 1941
Construction	$5,200,000	$5,500,000
Maintenance	4,166,000	4,000,000
Equipment (construction and maintenance)	67,138	60,000
Total	9,433,138	9,560,000

New Hampshire straightens roads

J. O. Morton, construction engineer, reporting for Commissioner F. E. Everett, states that the construction program in New Hampshire for 1940 was designed to eliminate many weak links in the trunk-line system. Projects were located where they would eliminate dangerous sections of alignment and grade. Old worn-out sections of narrow high-crowned roads which showed excessive maintenance cost were replaced and small towns where bad congestion develops were by-passed. Safety features included widening of pavement sections, elimination of deep drainage ditches adjacent to the road, flattening of slopes on shallow fills in order to eliminate the need for guard rails and installation of higher strength guard rails on dangerous fills. Special attention was paid to the convenience of the traveling public in passing over construction work. Where traffic had to be maintained, the dust nuisance was eliminated by incorporating an item in the contract for this specific purpose. As a result, the tourist benefited materially at no great cost to the state.

New construction in 1941 in New Hampshire will be applied only to those highways that fall in the strategic system. Weak links in the system will be rebuilt as funds permit. The present standards of the department meet military requirements.

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	11
Other Dustless Surface	80
Non-Dustless Surface	30
Graded and Drained	....
Total	121

EXPENDITURES	1940	Estimated 1941
Construction	$2,603,419	$1,911,000
Maintenance	3,213,071	3,380,000
Equipment (construction and maintenance)	9,000	20,000
Total	5,825,490	5,311,000

Relocated highway on Afton Mountain in Virginia, part of the Blue Ridge, to eliminate "S" curves and "hairpin" turns.

Winter maintenance in Vermont

H. E. Sargent, commissioner and chief engineer of the Vermont Department of Highways, reports that nearly 45 per cent of the maintenance expenditure in Vermont now is for winter roads, on which the public expects to drive as rapidly in winter as in summer, and generally does. Surface treatment on summer maintenance work has changed from a light bituminous material and sand cover to a heavy bituminous material with a stone cover, which increases the life of the treatment many times. Excellent results have been obtained with screened material, not washed, in making bituminous-mix roads. A very light bituminous material is applied first, and later a heavy bituminous material. This keeps the fine material from segregating.

It is expected that federal-aid funds and the state funds used to match them will be spent on the roads of the strategic highway network in Vermont in 1941. This will result in neglecting other roads in need of improvement, unless the federal government makes some special provision for the military roads.

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	19
Other Dustless Surface	128
Non-Dustless Surface	....
Graded and Drained	....
Total	147

EXPENDITURES	1940	Estimated 1941
Construction	$2,925,000	$2,925,000
Maintenance	1,769,000	1,769,000
Equipment (construction and maintenance)	43,000	43,000
Total	4,737,000	4,737,000

Massachusetts road work

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	31
Other Dustless Surface	5
Non-Dustless Surface	....
Graded and Drained	....
Total	36

EXPENDITURES	1940	Estimated 1941*
Construction	$1,780,702	$1,781,000
Maintenance	5,076,490	5,076,000
Equipment (construction and maintenance)	221,820	222,000
Total	7,079,012	7,079,000

* Unofficial estimate

Rhode Island divides main roads

G. H. Henderson, deputy director and chief engineer of the Division of Roads and Bridges, reports that in Rhode Island the dual-type and four-lane roads now are approaching standardization on a design having a raised, curbed median island, loamed

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	15.0
Other Dustless Surface	0.4
Non-Dustless Surface	....
Graded and Drained	....
Total	15.4

EXPENDITURES	1940	Estimated 1941
Construction	$2,400,000	$2,600,000
Maintenance	980,000	1,100,000
Equipment (construction and maintenance)	175,000	225,000
Total	3,555,000	3,925,000

and seeded with grass. The average width of this type of island is 6 ft., but it is proposed to increase the width on future projects wherever possible. The state has made good progress in controlling the type of cracks widely encountered in the surface of sheet asphalt pavement.

Connecticut extends parkway

Connecticut is forging ahead in the development of a limited access parkway system, says E. C. Welden, deputy highway commissioner, reporting for Commissioner Wm. J. Cox. The first unit of Merritt Parkway, was opened for its entire length of 37.2 miles in September, 1940. The section of Wilbur Cross Parkway that connects the Merritt Parkway with U. S. Route 1, has been completed, a second section carrying this parkway five miles nearer to New Haven is under construction, and a third section near the northern boundary of the state has been completed.

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration	46.9
Other Dustless Surface	10.7
Non-Dustless Surface	....
Graded and Drained	11.4
Total	69.0

EXPENDITURES	1940	Estimated 1941
Construction	$10,233,000	$11,233,000
Maintenance	2,982,000	2,982,000
Equipment (construction and maintenance)	326,000	326,000
Total	13,541,000	14,541,000

The state also has built a considerable mileage of divided highway on its main through route. Grade separations are projected at all critical points in this reconstruction work.

Over 500 miles of the 2,300 in the Connecticut state system have been designated for first and second priorities in strategic highway systems. It has been estimated that $21,000,000 will be required to provide additional grading, drainage, resurfacing, shoulder construction, bridge and structure changes.

Middle Atlantic States

New York builds test road

During the year New York State put into service a large section of four-lane concrete pavement on the new Storm King Highway, in which are many panels about 90 ft. long made up of six different blends of portland and natural cement, and some with admixtures of vinsol resin to determine the effect of blending and admixtures on the scaling of concrete.

New York State is building its main roads to standards higher than those required for military roads, using an H-20 bridge loading, hence concentration of federal-aid funds on roads of the strategic system will make no change in current practice.

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	207.5
Other Dustless Surface	20.0
Non-Dustless Surface	20.0
Graded and Drained	16.0
Total	263.5

EXPENDITURES	1940	Estimated 1941
Construction	$18,848,946	$18,500,000
Maintenance	8,500,000	9,300,000
Equipment (construction and maintenance)	700,000	700,000
Total	28,043,946	28,500,000

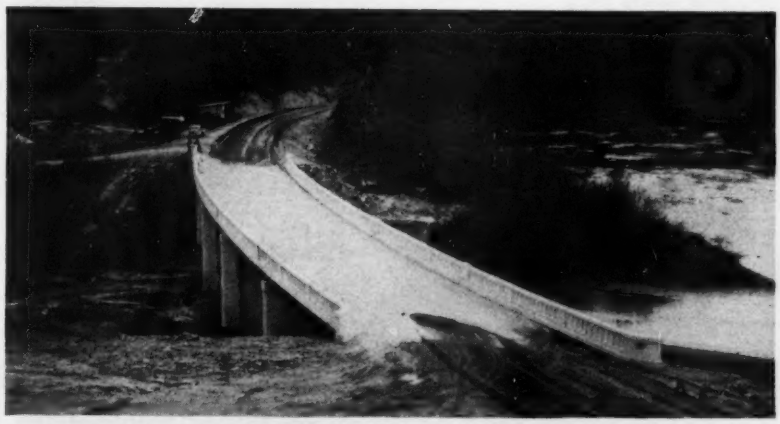
Pennsylvania widens many roads

Pennsylvania is using a designed mix for its concrete pavement based on the specific gravity of the aggregate, reports T. C. Frame, chief engineer, Department of Highways. Dur-

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	400
Other Dustless Surface	*1,750
Non-Dustless Surface	....
Graded and Drained	....
Total	2,150

*Incl. 450 mi. bituminous widening of existing roads

EXPENDITURES	1940	Estimated 1941
Construction	$38,000,000	$40,000,000
Maintenance	17,000,000	18,500,000
Equipment (construction and maintenance)	1,000,000	1,000,000
Total	56,000,000	59,500,000



Above, left, crossing of the Weber River near Unitah, Utah. The spans are rolled beams, the curve being introduced by cutting the lower flanges free and welding in an extension to the web plates. This gives increased moment of inertia without flange reinforcement and adds to the appearance. Below, right, Ivy River Bridge in Madison County, North Carolina, a 30-ft. roadway on reinforced concrete girders.

ing the year, the state widened 450 miles of existing roads with bituminous material, the work being done largely by the WPA. Widening will be continued in 1941 if possible.

New Jersey expands program

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	29.3
Other Dustless Surface	
Non-Dustless Surface	0.8
Graded and Drained	27.6
Total	57.7

EXPENDITURES	1940	Estimated 1941
Construction	$10,974,000	$15,000,000*
Maintenance	3,300,000	3,300,000
Equipment (construction and maintenance)	310,000	200,000
Total	14,584,000	18,500,000

* Unofficial estimate.

Delaware builds test roads

W. W. Mack, chief engineer, reports that Delaware built during 1940 a soil-cement road about three miles long and in the same vicinity a tar and asphalt stabilized road about four miles long. Both are through the same types of soil and carry about the same amount of traffic, thus they are expected to give a valuable comparison of the two types. Delaware now is giving more attention to the material that goes into shoulders, specifying that borrow for shoulders must meet specifications for selected material as set up by the soil laboratory.

The preparedness program is not expected to have any material effect on road work in Delaware. Most of the work planned for 1941 is to be on roads of the strategic network.

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	27.8
Other Dustless Surface	13.8
Non-Dustless Surface	0.6
Graded and Drained	24.6
Total	66.8

EXPENDITURES	1940	Estimated 1941
Construction	$1,327,556	$1,500,000
Maintenance	943,526	1,000,000
Equipment (construction and maintenance)	60,128	60,000
Total	2,331,210	2,560,000

Maryland figures missing

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	
Other Dustless Surface	
Non-Dustless Surface	
Graded and Drained	
Total	

EXPENDITURES	1940	Estimated 1941
Construction		
Maintenance		
Equipment (construction and maintenance)		
Total		

No mileage figures or expenditures for Maryland are available.

Southern States

Virginia eliminates curves

Outstanding work for 1940 in Virginia, according to Chas. B. Leech, Jr., office engineer, reporting for C. S. Mullen, chief engineer of the Department of Highways, included considerable widening of heavily traveled highways and the elimination of dangerous S and hairpin curves on some of the mountain roads. On the Eastern Shore a chain of six bridges was completed at a cost of nearly half a million dollars to join Chincoteague Island with the mainland.

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	220
Other Dustless Surface	155
Non-Dustless Surface	21
Graded and Drained	36
Total	432

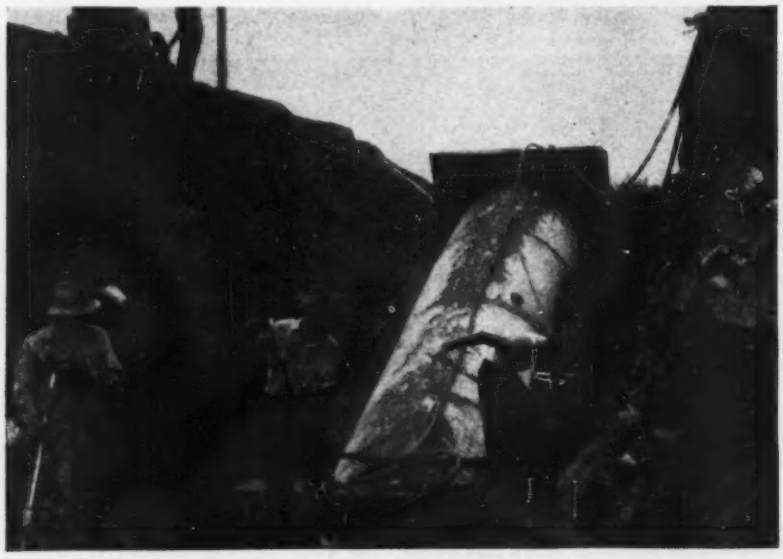
EXPENDITURES	1940	Estimated 1941
Construction	$12,799,000	$15,076,200
Maintenance Equipment (construction and maintenance)	2,887,000	2,860,000
Total	15,686,000	17,936,000

West Virginia extends surfacing

Burr H. Simpson, commissioner of the State Road Commission of West Virginia, reports that operations in 1940 were largely centered on surface treatment, 468 miles of such work having been done during the fiscal year on primary roads and 124 miles on secondary roads. Macadam base construction totaled 105 miles, of which 85 miles was on the primary system.

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	103
Other Dustless Surface	602
Non-Dustless Surface	172
Graded and Drained	92
Total	969

EXPENDITURES	1940	Estimated 1941
Construction	$6,154,168	$9,526,000
Maintenance	5,600,000	5,600,000
Equipment (construction and maintenance)		
Total	11,754,168	15,126,000



Soil mechanics applied to culvert construction in Nebraska. Water was added to the backfill to obtain the optimum moisture content before tamping it into place around the culvert with air tampers.

North Carolina widens its roads

W. Vance Baise, North Carolina state highway engineer, reports no unusual changes in their operations in 1940. Widening of existing roads is to be given special attention in the new work.

Curtailment of work on roads off the military system will result in

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	286
Other Dustless Surface	280
Non-Dustless Surface	
Graded and Drained	62
Total	628

EXPENDITURES	1940	Estimated 1941
Construction	$10,290,000	$9,700,000
Maintenance	12,500,000	15,500,000
Equipment (construction and maintenance)	700,000	700,000
Total	23,490,000	25,900,000

1941 if federal-aid funds allocated to North Carolina are to be spent chiefly on the strategic network. State officials hope that Congress will provide special funds for the military system in order to make this curtailment of work unnecessary.

Roads widened in South Carolina

J. S. Williamson, South Carolina state highway engineer, reports that widening and improving of state highways in and adjacent to cities, undertaken a few years ago as a work-relief measure, is now showing its value in speeding up traffic and in providing relief for the traffic that is growing out of the expansion of war industries. More attention is to be given to such work in future highway planning. In rural areas the state has been doing considerable widening of shoulders, and on the heavily traveled main highways it has been adding a bituminous surface treatment to the shoulders.

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	9
Other Dustless Surface	162
Non-Dustless Surface	....
Graded and Drained	111
Total	282

EXPENDITURES	1940	Estimated 1941
Construction	$7,950,000	$7,950,000
Maintenance	2,837,000	2,837,000
Equipment (construction and maintenance)	520,000	520,000
Total	11,307,000	11,307,000

National defense activities are expected to have considerable effect on the design of new highway construction in South Carolina. While for several years the state has been using stabilized-earth type bases for bituminous surface treatment, the heavy loads required of the highways in the moving of material for the defense program, and in moving heavy army equipment, makes bases designed to support these heavy loads essential.

Plant mix extended in Georgia

Georgia made large additions to its plant-mix and road-mix surfacing during 1940, having added 1,478 miles of such bituminous surfacing.

MILEAGE BUILT*	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	125
Other Dustless Surface	1,478
Non-Dustless Surface	870
Graded and Drained	759
Total	3,232

* Let to contract or under construction.

Straightening the National Road in Franklin County, Ohio. The arch bridge under construction in the center will replace the truss bridge at the right.

EXPENDITURES	1940	Estimated 1941
Construction	$15,572,786	$15,000,000
Maintenance	1,675,271	1,500,000
Equipment (construction and maintenance)	2,718,070	500,000
Total	19,966,127	17,000,000

Military roads in Florida

The need for military roads in Florida is great due to the large number of new training areas. The highway department has asked the legislature for $3,000,000 for this work and will be unable to meet the needs of the several military areas without it.

EXPENDITURES	1940	Estimated 1941
Construction	$17,436,516	$14,000,000
Maintenance	3,730,981	5,000,000
Equipment (construction and maintenance)	435,736	1,000,000
Total	21,603,233	20,000,000

Alabama uses higher standards

Chris J. Sherlock, Alabama state highway director, estimates that there will be a slight decrease in mileage of various types of roads constructed in that state during the coming year as compared to 1940, due to the higher standards that now are being built into the state's highways.

Alabama has no information as to the increase in traffic on the strategic highway system that will result from the preparedness operations, but state officials believe that if it is necessary to over-build roads solely for military use the state should participate in the construction only to the extent of the expenditure required to meet present and future local traffic needs within a reasonable number of years.

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	10
Other Dustless Surface	826
Non-Dustless Surface	85
Graded and Drained	647
Total	1,568

EXPENDITURES	1940	Estimated 1941
Construction	$9,321,000	$8,500,000
Maintenance	3,262,000	2,500,000
Equipment (construction and maintenance)	369,000	300,000
Total	12,952,000	11,300,000

Mississippi starts coast highway

Notable in the work undertaken by Mississippi during the past year, according to R. A. Harris, chief engineer, is completion of the first section of a dual highway along the Gulf Coast to replace the narrow road that serves both as a through highway and as access to the coast resorts. The approaching completion of Mississippi's big highway program financed by a special bond issue is indicated by an anticipated reduction in highway expenditures from nearly $18,000,000 in 1940 to a little over $4,000,000 in 1941.

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	158
Other Dustless Surface	190
Non-Dustless Surface	11
Graded and Drained	484
Total	843

EXPENDITURES	1940	Estimated 1941
Construction	$15,631,689	$2,313,000
Maintenance	2,056,573	1,800,000
Equipment (construction and maintenance)	200,000	75,000
Total	17,888,262	4,188,000

Mississippi is making surveys and preparing plans for the addition of a new lane to U. S. Highway 49 be-

tween Hattiesburg and Camp Shelby to improve access to that camp. No actual expenditures have yet been authorized.

Bridges built by Louisiana

Bridge construction played a prominent part in the 1940 highway program in Louisiana, according to Harry B. Henderlite, chief engineer, department of highways, the big bridge over the Mississippi River at Baton Rouge having been completed, also bridges over Caddo Lake. Twelve Mile Bayou and Cross Bayou, over the New Basin Canal on the Airline Highway at New Orleans and over the Charenton drainage and navigation canal in the Atchafalaya floodway. The department also continued the successful application of hydraulic construction to embankment work.

Louisiana is one of the few states in which camp access road programs have taken definite shape, the widening of the pavement between Kingsville and Camp Livingston having been definitely included in the 1941 program.

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	40
Other Dustless Surface	19
Non-Dustless Surface	173
Graded and Drained	59
Total	291

EXPENDITURES	1940	Estimated 1941
Construction	$9,919,800	$18,282,000
Maintenance	1,198,890	3,500,000
Equipment (construction and maintenance)	.....	250,000
Total	11,118,690	22,032,000

Kentucky widens roads

Kentucky included 13 miles of extra width paving in the 181 miles of hard surfacing that it did in 1940, according to T. H. Cutler, state highway engineer.

Kentucky does not have sufficient funds to meet the War Department's needs in 1941. If no additional funds are furnished and if the state is required to spend all available funds on strategic highways there will be no money for other state road work.

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	181
Other Dustless Surface	192
Non-Dustless Surface	....
Graded and Drained	185
Total	558

EXPENDITURES	1940	Estimated 1941
Construction	$11,000,000	$10,000,000
Maintenance	5,500,000	6,000,000
Equipment (construction and maintenance)	425,000	400,000
Total	16,925,000	16,400,000

Footpaths are being added to many highways to take pedestrians off the pavement. This walk is along the Milwaukee-Waukesha highway.

Roadsides are getting more attention. This is the relocated road around Surry Mountain Dam in New Hampshire.

Much work in Tennessee

L. N. Means, office engineer, Tennessee Department of Highway, reports no unusual developments.

Tennessee has 982 miles in the first priority class on the strategic network. Much of this can be brought up to standards by widening and surface reconstruction, but 278 miles must be reconstructed and a number

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	28.1
Other Dustless Surface	24.9
Non-Dustless Surface	20.3
Graded and Drained	32.0
Total	105.3

EXPENDITURES	1940	Estimated 1941
Construction	$4,661,498	$9,626,426
Maintenance	2,400,000	2,400,000
Equipment (construction and maintenance)	.....	.....
Total	7,061,498	12,026,426

of bridges must be rebuilt. The total cost of the work is estimated at $38,100,000. Even if all available state and federal funds can be concentrated on this system, only a small part can be rebuilt each year.

Middle Western States

Ohio expands safety work

Ohio is giving increased attention to safety, according to Murray D. Shaffer, chief engineer, location and right-of-way, Ohio Department of State Highways. The bureau of traffic and safety, set up as an independent department in 1939, is to be expanded by the addition of six more field traffic engineers, bringing the total to twelve, one for each division of the department. During the year, maintenance work financed by the WPA covered 473 miles.

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	358
Other Dustless Surface	2,271
Non-Dustless Surface	10
Graded and Drained	2
Maintenance financed WPA projects	473
Total	3,114

EXPENDITURES	1940	Estimated 1941
Construction	$26,165,000	$24,000,000
Maintenance	17,732,000	15,000,000
Equipment (construction and maintenance)	668,000	500,000
Total	44,565,000	39,500,000

Divided highways in Indiana

Construction of divided-lane highways has continued at an increased rate in Indiana, according to Earl B. Lockridge, chief engineer. Experimental work on fill compaction on some of the more important highways has shown good results. A small mileage of reflectorized curve and center strips has been constructed as an experimental safety feature. The maintenance department also has developed a better type of paint for center line marking. An improvement has been made in the regulations for marking state highways and state routes through cities. In both maintenance and construction, special attention is being given to improving the appearance of the roadside by sodding shoulders and seeding portions of the right-of-way which are not sodded.

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	171
Other Dustless Surface	339
Non-Dustless Surface	....
Graded and Drained	137
Total	647

EXPENDITURES	1940	Estimated 1941
Construction	$12,356,457	$16,411,000
Maintenance	4,500,400	4,500,000
Equipment (construction and maintenance)	38,923	.....
Total	16,895,780	20,911,000

The Indiana Highway Commission is planning to give the maximum amount of attention to roads which may be designated as having defense priorities, but definite plans are awaiting specific instructions from the federal government.

Illinois improves intersections

Illinois is placing special emphasis on the design of intersections, according to Ernst Lieberman, chief highway engineer. Each intersection is designed to meet its peculiar requirements in promoting safe and free movement of traffic. There is a definite trend toward channelization. Illinois also has carried on during the year extensive work in checking the "pumping action" of pavement slabs.

Meeting the requirements of the defense highway network will place many roads in Illinois in a higher priority than purely peacetime usage would justify. This will force deferment of projects which are of much greater importance from the standpoint of civilian use. About $4,000,000 of the $10,500,000 that Illinois will have for the federal-aid system work in 1941 will go to defense projects. $57,500,000 will be required to bring the strategic network up to standards and another $15,000,000 will be required for access roads.

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	167
Other Dustless Surface	112
Non-Dustless Surface	86
Graded and Drained	104
Total	469

EXPENDITURES	1940	Estimated 1941
Construction	$19,800,000	$20,000,000
Maintenance	6,350,000	6,500,000
Equipment (construction and maintenance)	1,200,000	1,000,000
Total	27,350,000	27,500,000

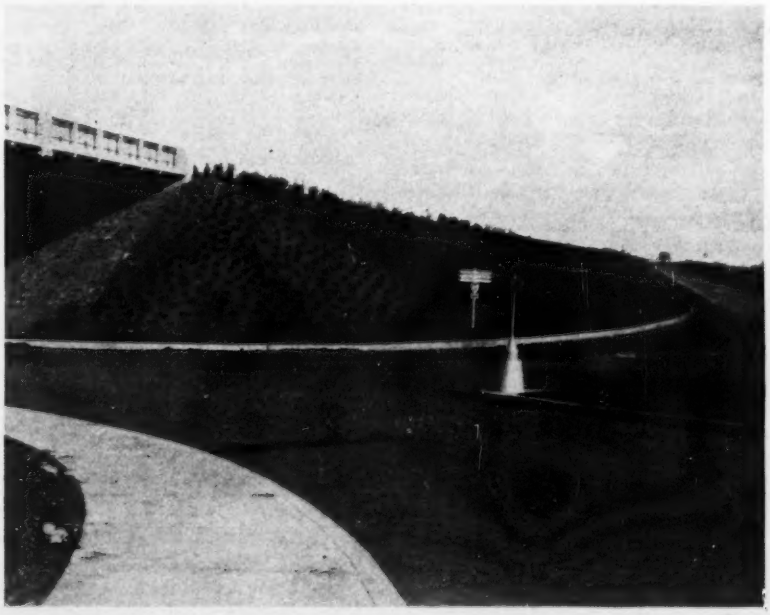
Wisconsin studies aggregates

E. L. Roettiger, state highway engineer of Wisconsin, reports that in 1940 much greater use was made of

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	50
Other Dustless Surface	107
Non-Dustless Surface	86
Graded and Drained	112
Total	355

EXPENDITURES	1940	Estimated 1941
Construction	$6,500,000	$6,500,000*
Maintenance	3,000,000	3,000,000
Equipment (construction and maintenance)	.....	.....
Total	9,500,000	9,500,000

*Unofficial estimate



Highway connecting ramp at the overcrossing on U.S. 99E at Albany, Oregon, showing careful treatment of the banks. Traffic for Corvallis and the coast town now passes under the main North-South highway at this point.

compaction methods in the construction of both roadbeds and aggregate surface courses. Much work also was done in the development of the graded aggregate type of surfacing, not only in regard to proper gradation, but also as to construction methods, optimum moisture content, type and quantity of binder material, desirable subgrade conditions, and compaction and densification methods. This type of surfacing now is being used on state highway work almost to the exclusion of the traffic-bound type.

Michigan tries new designs

H. C. Coons, deputy commissioner and chief engineer, reports that Michigan has constructed an 18-mile section of concrete pavement incorporating new ideas in highway testing, research and soils engineering, upon which the various innovations will be "road tested" during the next five years. In one section, 1,800 ft. in length, the "stress curing" principle was introduced. Other parts of the road were built in short sections and with various pavement thicknesses. Admixtures were varied and natural cement was used in combination with portland cement in some locations.

Michigan built the first military road project under the current national defense program, starting construction in September on an access road at Fort Custer near Battle Creek. It is described elsewhere in this issue.

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	257
Other Dustless Surface	904
Non-Dustless Surface	224
Graded and Drained	77
Total	1,462

EXPENDITURES	1940	Estimated 1941
Construction	$15,500,000	$11,778,500
Maintenance	6,900,000	6,515,000
Equipment (construction and maintenance)	250,000	200,000
Total	22,650,000	18,493,500

West of the Mississippi

Arterials extended in Minnesota

O. L. Kipp, assistant chief engineer of the Minnesota Highway Department, reports that Minnesota has given special attention to extension of arterial highways into the large cities and to belt-line roads. During 1940 a 7½-mile belt highway along the westerly side of Minneapolis was completed. It is on a 200-ft. right-of-way with four traffic lanes, parking lanes and service roads. Crossing of six railways and five highways are separated. Leading from this road into the city, the state has built 1½ miles of six-lane divided highway, the division being 64 ft. wide to permit two more lanes to be added and still maintain a wide median zone. A strip one-half block wide was acquired to increase the street width from 66 to 160 ft. Two sections of four-lane divided highway leading into St. Paul from the east and south also were built during the year.

Projects on the strategic highway system make up 30 per cent of the new program submitted by Minnesota to the Public Roads Administration and approved by that agency.

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	87
Other Dustless Surface	286
Non-Dustless Surface	314
Graded and Drained	436
Total	1,096

EXPENDITURES	1940	Estimated 1941
Construction	$10,634,338	$12,899,000
Maintenance	4,892,241	6,986,000
Equipment (construction and maintenance)	1,743,397	888,000
Total	17,269,976	20,773,100

Divided-lane highway just east of Kansas City on U. S. Route 50. Advantage was taken of the topography in locating the separated roads.

Mechanization cuts costs in Iowa

The trend towards completely mechanized grading equipment that has been noticeable for the past several years is now being reflected in a decrease in unit price bids for all classes of excavation work, according to C. Coykendall, engineer, estimates and contracts, Iowa State Highway Commission. This has permitted improvement in design practice as the decreased excavating costs make it possible to use better grades and flatter slopes.

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	172
Other Dustless Surface	18
Non-Dustless Surface	474
Graded and Drained	735
Total	1,399

EXPENDITURES	1940	Estimated 1941
Construction	$11,639,000	$11,000,000
Maintenance	3,668,000	4,000,000
Equipment (construction and maintenance)	400,000	.....
Total	15,707,000	15,000,000

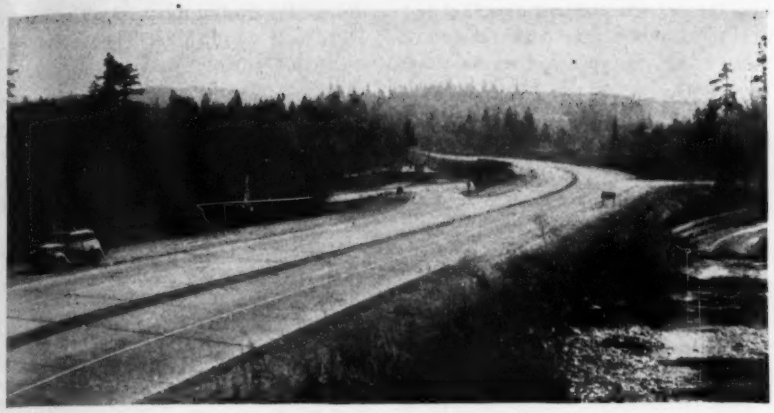
Missouri emphasizes safety

During 1940, efforts of the Missouri State Highway Commission were largely directed toward increasing road safety through modernization and improvement of the present system and toward extension of farm-to-market roads as far as funds would permit, according to C. W. Brown, chief engineer. A continuation of these directives is planned for 1941, but all possible consideration will be given to roads designated as part of the strategic highway system. Missouri is now on a pay-as-you-go basis.

The 1,142 miles of first priority mileage for the defense highway system in Missouri coincides generally

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	164
Other Dustless Surface	245
Non-Dustless Surface	225
Graded and Drained	99
Total	733

EXPENDITURES	1940	Estimated 1941
Construction	$13,581,200	$10,660,000
Maintenance	5,600,000	5,600,000
Equipment (construction and maintenance)	.....	.....
Total	19,181,200	16,260,000



Four-lane highway between Seattle and Issaquah showing a typical grade separation for an intersecting road.

with heavy-traffic arteries that are important for ordinary service. Much of this mileage was constructed in the early days of road building and now is more or less obsolete and in need of major improvement and reconstruction. However, the demand for improvement on the remaining 15,825 miles of the system is urgent and funds are limited.

Arkansas gets increased funds

Arkansas' construction program for 1940 was financed with federal funds made available through toll-bridge reimbursement accomplished by state action in freeing all state-owned and operated toll bridges in the spring of 1938, according to W. W. Mitchell, director of highways for the state.

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	15
Other Dustless Surface	125
Non-Dustless Surface	....
Graded and Drained	28
Total	168

EXPENDITURES	1940	Estimated 1941
Construction	$3,798,839	.....
Maintenance	3,345,000	.....
Equipment (construction and maintenance)	.....	.....
Total	7,143,839	.....

Low-cost roads in North Dakota

North Dakota's road work in 1940 was concentrated entirely on roads classified by the Public Roads Administration, as "other dustless surface," 178 miles of such road having been built, according to Z. E. Sevison, state highway engineer.

The preparedness program made no change in the 1940 roads program in North Dakota, but surveys and designs are in progress under the provisions of the Federal Highway Act of 1940. Bids will be called as soon as the federal-aid funds are available.

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	....
Other Dustless Surface	178
Non-Dustless Surface	....
Graded and Drained	....
Total	178

EXPENDITURES	1940	Estimated 1941
Construction	$2,752,350	$2,950,000
Maintenance	1,432,171	1,625,000
Equipment (construction and maintenance)	75,897	100,000
Total	4,260,418	4,675,000

New methods used in South Dakota

E. W. Meeker, state highway engineer of South Dakota, reports new developments in that state in connection with the base course for bituminous construction. Heretofore the department built stabilized gravel base courses to a thickness of 4 in. of penetration treatment using SC-1 oil and a blotter-type treatment on top using SC-4 with the addition of about 125 tons per mile of blotter-course materials. Now, following the SC-1 penetration treatment, there is an interim treatment consisting of about 400 tons per miles of cover coat material of coarse gravel passing a ¾-in. screen, densely graded, which is road mixed with SC-4 road oil and laid down for a width of 24 ft. Following this treatment, if the construction project is upon a highway on which it is justifiable to place a regulation 2-in. bituminous treatment wearing force within one year, it is not necessary to make further treatment except that of a flush coat of SC-4. On some of the projects where traffic is not sufficiently heavy to warrant the placing of the wearing course mat within a year, this interim mat is covered with a seal coat consisting of a flush coat of RC-1 cutback and an application of stone chips at about 17 lb. of ¾-in. stone per square yard applied to RC-3 cutback asphalt and rolled in. This type of finishing coat applied to the interim mat will, it is believed, lengthen the life of the interim mat and carry traffic for a number of years before it will be necessary to apply the regulation bituminous wearing mat.

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	12
Other Dustless Surface	237
Non-Dustless Surface	81
Graded and Drained	307
Total	637

EXPENDITURES	1940	Estimated 1941
Construction	$4,265,000	$4,000,000
Maintenance	2,300,000	1,900,000
Equipment (construction and maintenance)	90,000	100,000
Total	6,655,000	6,000,000

The South Dakota construction program for 1941 will include a number of new projects on the strategic network. No bridges on the network lacks adequate carrying capacity, but some will require widening. Plans for the strategic network are still tentative.

Nebraska cuts road costs

Nebraska has continued its low-cost pavements, reports A. C. Tilley, state engineer. This emphasis on low costs is due to the fact that since 1919, Nebraska has been on a pay-as-you-go basis, yet it has large highway mileage, large area and relatively small funds for construction. During the past year, new and improved designs and procedures were put into practice in the field of soil-cement stabilization, bituminous stabilization, crushed rock foundation coarse construction, bituminous surface treatment and selective placement of soils. Subgrade stabilization was provided for concrete pavement

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	17
Other Dustless Surface	606
Non-Dustless Surface	184
Graded and Drained	47
Total	854

EXPENDITURES	1940	Estimated 1941
Construction	$9,000,000	$5,665,000
Maintenance Equipment (construction and maintenance)	2,680,000	3,000,000
Total	11,680,000	8,665,000

when required. Large scraper units were put into more general use during 1940, and a large part of the flexible type pavement was constructed with traveling mixing plants.

Kansas makes climate a factor

R. B. Wills, Kansas state highway engineer, reports that during the year 1940 an earnest effort was made to correlate the three major points in connection with the design of a surface, namely, traffic, soils and rainfall. Under this theory it has been found possible to build much lighter surfaces in areas of the state where rainfall is exceedingly low, but where traffic and soil conditions were similar to those in areas where higher types of surfaces have been found necessary in the past.

Use of Kansas highway funds on military roads will limit the amount of money available for other roads.

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	24
Other Dustless Surface	529
Non-Dustless Surface	153
Graded and Drained	170
Total	876

EXPENDITURES	1940	Estimated 1941
Construction	$8,822,105	$7,630,000
Maintenance	3,350,000	3,500,000
Equipment (construction and maintenance)	1,079,500	1,080,000
Total	13,251,605	12,210,000

Oklahoma figures missing

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	
Other Dustless Surface	
Non-Dustless Surface	
Graded and Drained	
Total	

EXPENDITURES	1940	Estimated 1941
Construction		
Maintenance		
Equipment (construction and maintenance)		
Total		

* No figures for mileage built in Oklahoma or for expenditures are available.

Texas cuts maintenance costs

The average cost per mile of maintenance of all state highways in Texas has declined from $355.13 in 1931 to $294.17 in 1940, according to E. J. Amey, administrative assistant, Texas Highway Department. This cost now includes traffic services not included in the earlier figures.

The effect of the national preparedness program on the Texas Highway Department work is still uncertain. Roads of the strategic network in the State total 6,375 miles, and the department assumes that federal aid funds will be concentrated on these roads. Surveys for access roads to camps not on the state highway system have been made, but as yet no work has been done for lack of available funds.

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	126
Other Dustless Surface	1,302
Non-Dustless Surface	682
Graded and Drained	516
Total	2,626

EXPENDITURES	1940	Estimated 1941*
Construction	$27,725,472	$26,700,000
Maintenance	9,222,055	9,000,000
Equipment (construction and maintenance)	799,433	800,000
Total	37,746,960	36,500,000

*Unofficial estimate

Montana extends soil studies

D. A. McKinnon, a state highway engineer, reports highly satisfactory results from the use of a sand-soil blend and asphaltic binders for base construction on the Miles City-Broadus Highway, also from the use of fine sand stabilized with MC-3 asphaltic binder on 9.9 miles of the Forsythe-Roundup highway. For the sand-soil blend, MC-3 was used for six miles and emulsified asphalt for six miles. The finished project represents the fruition of considerable experimental work in areas where mineral aggregates are scarce. Continuing the trend established in 1939, the road was oil-treated from shoulder to shoulder and the wearing surface was sealed with stone chips and an application of 95+ road oil.

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	
Other Dustless Surface	194
Non-Dustless Surface	380
Graded and Drained	291
Total	865

EXPENDITURES	1940	Estimated 1941
Construction	$6,260,000	$5,700,000
Maintenance	1,880,000	1,940,000
Equipment (construction and maintenance)	264,000	260,000
Total	8,404,000	7,900,000

Soil studies cut Wyoming costs

Frank Kelso, superintendent of the Wyoming Highway Department, reports that studies made by the materials engineers have resulted in increased use of local road-building materials and the cutting down of the cost per mile of base courses and oil surface. The engineers of the department have continued to make more thorough preliminary investigations as to soil conditions. They now design the entire roadway structure, subgrade, base course and top course to fit the soil conditions. Practically the entire state highway system, including several hundred miles of secondary feeder road, now have an oil surface.

Some of this surface on the lighter traveled roads and in the mountains consists of a light stone-chip armor coat. Quite a large amount of the funds for 1941 will go to putting these stone-chip armor coats on other highways.

Wyoming has no funds for widening out the strategic network or for building camp access roads, and it is expected that the federal government will make funds available for what widening work is necessary and for the access roads. Construction work will continue on the same basis as the past, which is to straighten and widen as much as necessary for normal peak-time traffic on heavily traveled roads, and improve some additions to the main highway system.

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	
Other Dustless Surface	371.9
Non-Dustless Surface	11.5
Graded and Drained	55.4
Total	438.8

EXPENDITURES	1940	Estimated 1941*
Construction	$4,300,000	$3,700,000
Maintenance Equipment (construction and maintenance)	750,000	750,000
Total	5,050,000	4,450,000

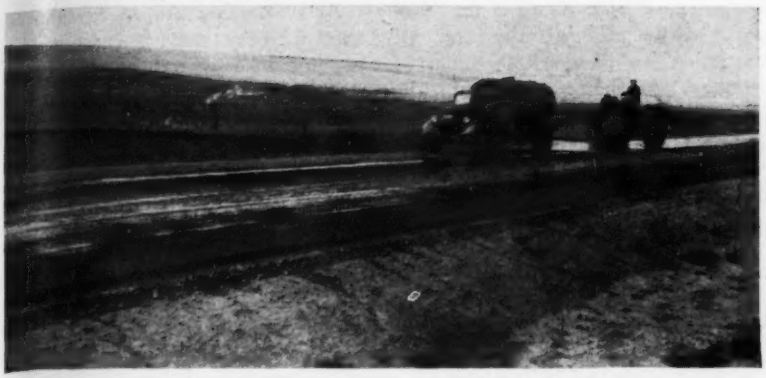
*Unofficial estimate

Colorado uses bituminous types

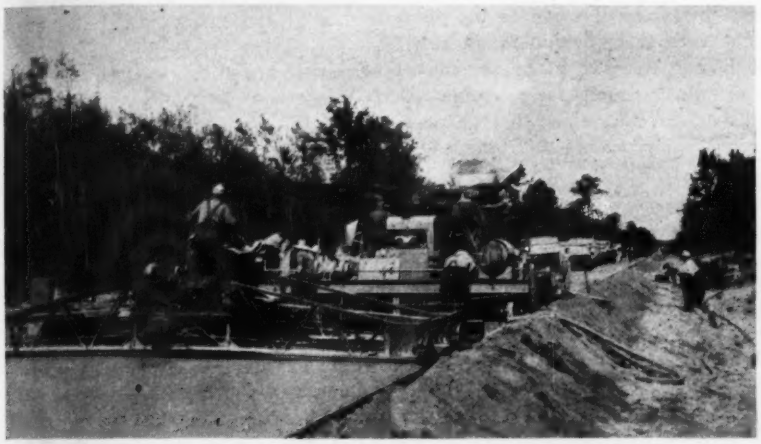
W. M. Williams, director of publicity, reports that road construction in Colorado during 1940 was concentrated largely on road-mix and bituminous penetration. If Colorado is required to concentrate expenditures on highways of the defense system it will be in a difficult position in meeting more urgent needs on other roads.

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	15
Other Dustless Surface	529
Non-Dustless Surface	
Graded and Drained	115
Total	659

EXPENDITURES	1940	Estimated 1941
Construction	$5,400,000	$5,500,000
Maintenance	1,315,000	1,315,000
Equipment (construction and maintenance)	185,000	185,000
Total	6,900,000	7,000,000



Watering and rolling base course material on Montana Route 16 near Sidney.



Michigan built a test road 17.7 miles long during 1940 in which 10.1 miles is to be used to study design principles and 7.6 miles to study the durability of concrete in a variety of large scale field tests.

Grading on a new 4½-mile road between Hardwick and Morrisville, Vermont. The road is to have a double tack coat of refined tar with pea stone surfacing.

New Mexico improves road surfaces

The New Mexico 1940 program was characterized by special attention to retopping, roadside improvement, widening and sealing, according to C. O. Faulk, reporting for B. G. Dwyre, state highway engineer, such work having been carried forward on 150 miles of highway.

New Mexico has not learned definitely whether federal-aid funds will have to be spent for widening of the strategic network highways, but if this is necessary it will result in the reduction of the mileage of obsolete highway on the federal-aid systems that can be reconstructed as part of the 1941 program.

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	26
Other Dustless Surface	520
Non-Dustless Surface	336
Graded and Drained	220
Total	1,102

EXPENDITURES	1940	Estimated 1941
Construction	$5,000,000	$6,000,000
Maintenance	1,295,000	1,500,000
Equipment (construction and maintenance)	470,000	250,000
Total	6,765,000	7,750,000

Far West States

Shoulder work planned in Idaho

Idaho plans to do some pioneering work in the stabilization of shoulders with cement in 1941, according to C. P. Humphrey, director of highways.

All available funds in Idaho are to be concentrated on the first priority military roads.

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	0.6
Other Dustless Surface	235.3
Non-Dustless Surface	113.4
Graded and Drained	
Total	349.3

EXPENDITURES	1940	Estimated 1941
Construction	$3,110,000	$3,638,000
Maintenance	1,510,000	1,600,000
Equipment (construction and maintenance)	30,000	100,000
Total	4,650,000	5,338,000

Lanes widened in Utah

H. V. Richards, statistical engineer, reporting for Ezra C. Knowlton, chief engineer of the Utah State Road Commission, states that the surface width on two-lane roads has been increased to 24 ft., so as to provide 12-ft. lanes of travel instead of the former 11-ft. lanes, which in

turn evolved from the old 18-ft. standard roadway. The department has made considerable advance in the use of soil studies in embankment construction. and embankment building methods now include watering and rolling or tamping in 8-in. layers.

The Utah highway program for 1941 has not been modified in any particular extent for the preparedness program, chiefly because the program has not taken definite form. All but 200 miles of the 1,300 miles of strategic network roads within the state are on the principal U.S. numbered highways. Many of these roads need widening and straightening to bring them up to military standards.

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	17
Other Dustless Surface	193
Non-Dustless Surface	87
Graded and Drained	33
Total	330

EXPENDITURES	1940	Estimated 1941
Construction	$2,900,000	$3,000,000
Maintenance	1,200,000	1,200,000
Equipment (construction and maintenance)	250,000	200,000
Total	4,350,000	4,400,000

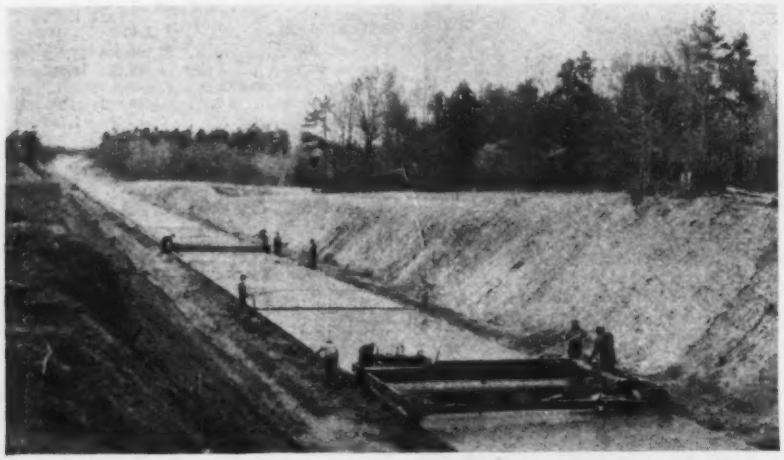
Arizona tests base stabilization

W. R. Hutchins, state highway engineer, reports that Arizona inaugurated two test sections of cement-stabilized base, one with a 2-in. oil-cake top and one with an emulsified oil and chat seal coat. An experiment of special interest is the spiking of a very thin copper strip into the pavement as a traffic guide in an effort to find something more permanent than the painted strip commonly used on pavements for that purpose.

Arizona's first project on the strategic highway system, using federal-aid funds for a road that is not now up to the necessary standards as to width, is now before the PRA for approval. It is expected to act as a guide for future work because, if the Army's high width standard is made mandatory it will automatically cut down the highway mileage built in 1941, due chiefly to the fact that widening in the very rough country in Arizona adds greatly to the cost.

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	7.8
Other Dustless Surface	209.4
Non-Dustless Surface	5.8
Graded and Drained	8.6
Total	231.6

EXPENDITURES	1940	Estimated 1941
Construction	$5,047,650	$4,477,700
Maintenance	1,207,634	1,500,000
Equipment (construction and maintenance)	1,187,948	1,225,000
Total	7,443,232	7,202,700



Building a two-lane concrete highway on a new location in North Carolina.

Bituminous treatment on Highway 66 between Ashfork and Seligman, Arizona.

Shoulders widened in Nevada

No radical changes are contemplated in 1941 in Nevada, according to C. V. Melarkey, office engineer, reporting for Robert A. Allen, state highway engineer. Shoulders are now being widened and stabilized with a road-mixed asphaltic surface.

A majority of the available funds in Nevada will be spent on the military road system to bring the first priority roads up to the required standards or better. Special attention will be given to widths, shoulders and turnout shoulders for army convoys.

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	....
Other Dustless Surface	188.8
Non-Dustless Surface	33.5
Graded and Drained	....
Total	222.3

EXPENDITURES	1940	Estimated 1941
Construction	$2,564,901	$2,417,000
Maintenance	763,075	875,000
Equipment (construction and maintenance)	85,618	75,000
Total	3,413,594	3,367,000

Washington opens bridge road

In the State of Washington special effort was concentrated on completion of the new four-lane highway between Seattle and Issaquah concurrently with the completion of the Lake Washington Pontoon Bridge which forms a link in that route, according to James A. Davis, acting director of highways. Heavy grading and paving on this road under ad-

verse weather conditions presented many perplexing problems. Reconstruction of existing highway facilities to new design standards formed a large part of the 1940 program.

The Washington Department of Highways has prepared estimates for the modernization of highways included in the strategic network, but it is not yet definitely known what projects will have to be built within the immediate future.

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	8
Other Dustless Surface	357
Non-Dustless Surface	163
Graded and Drained	....
Total	528

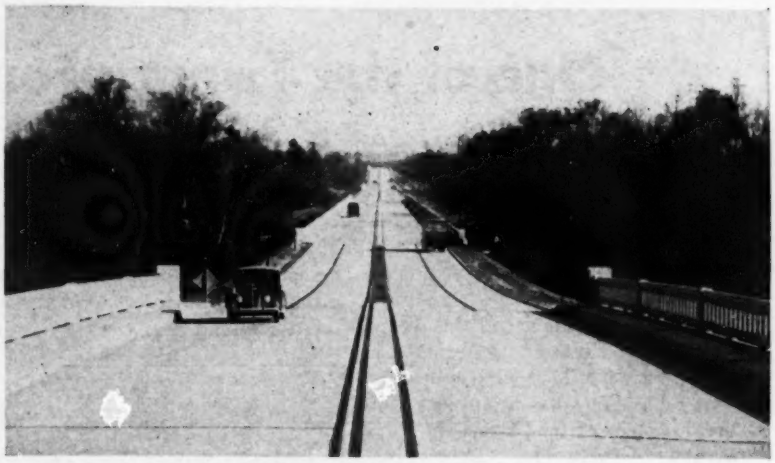
EXPENDITURES	1940	Estimated 1941
Construction	$7,500,000	$7,000,000
Maintenance	5,400,000	4,700,000
Equipment (construction and maintenance)	.....	.....
Total	12,900,000	11,700,000

Oregon aids traffic in cities

R. H. Baldock, chief engineer, Oregon State Highway Commission, reports that in Oregon special attention is now being given to the control of traffic on state highway routes through the cities by means of islands, positive separation of traffic lanes and signal lights. In order to keep pedestrians off the highway pavement in suburban district, provision has been made in some of the paving contracts for the construction of asphaltic concrete footpaths. Highway activities during 1940 included completion of revision of U. S. 99 over the Siskiyou Mountains, an extension of the four-lane highway between Portland and Oregon City, and through Oregon City to avoid traffic congestion in the business district, opening of the Willamette highway cutoff on state route 58 through the Cascade Mountains to Klamath Falls and Weed, Calif. Also, the state and the War Department let a joint contract for dredging in the Columbia River, which includes the construction of a hydraulic fill for the new water-grade highway in the Columbia River gorge between Portland and Hood River.

MILEAGE BUILT	194
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	77
Other Dustless Surface	394
Non-Dustless Surface	270
Graded and Drained	165
Total	915

EXPENDITURES	1940	Estimated 1941
Construction	$6,800,000	$7,750,000
Maintenance	3,650,000	3,930,000
Equipment (construction and maintenance)	330,000	300,000
Total	10,780,000	11,980,000



An air-line location was selected in relocating U. S. 80 in Mississippi to bypass the city of Jackson. This view is from the Illinois Central overpass to the Pearl River Bridge and another railroad overpass.

North Ave., a main approach to Chicago and the dividing line between Chicago and Oak Park, has been widened from two 20-ft. pavements separated by a 17-ft. strip left for trolley tracks to a full width of 68 ft. curb to curb. The 4-ft. median curb and 6½-ft. strip of pavement on the Oak Park side (right) was built by the state. On the Chicago side a new 36-ft. pavement has been built.

California tries stabilization

California built 34.8 miles of highway having a base stabilized with portland cement during 1940, according to C. H. Purcell, state highway engineer. A plant-mixed surfacing was put on this subgrade.

California has $38,000,000 available for construction during the next two years, and estimates that $150,000,000 will be required to bring roads of the strategic network up to the required standard, with $11,000,000 needed in addition for camp access roads. If expenditures are to be concentrated on the defense system, other federal-aid work will have to be materially curtailed.

MILEAGE BUILT	1940
Pavement (concrete, brick, asphalt, bituminous concrete and bituminous penetration)	47
Other Dustless Surface	324
Non-Dustless Surface	282
Graded and Drained	57
Total	710

EXPENDITURES	1940	Estimated 1941*
Construction	$16,450,000	$19,000,000
Maintenance	10,586,000	9,200,000
Equipment (construction and maintenance)	861,000	350,000
Total	27,897,000	28,550,000

*½ of biennial figure

One of the Twenty-Four Hundred

A SUBSTANDARD BRIDGE is the ultimate in bottlenecks. For vehicles too heavy, too broad or too high, it is more accurately described as a dead end. And since our strategic highway net of 75,000 miles contains some 2,400 of these substandard bridges, a huge program of bridge strengthening —or rebuilding—has been placed on the doorsteps of the forty-eight state highway departments. The big job is, of course, financial; if it were only technical these substandard bridges would not exist today. Military necessity, however, is providing an incentive to find the money, which soon will narrow the task to one of engineering and construction.

One of the first substandard bridges to receive attention is an old wrought-iron through truss over the Green River near Greenfield, Mass. Built in 1895, it is now inadequate for the increasingly heavy traffic on Massachusetts Route 2, the Mohawk Trail. Comparing the economics of a new bridge against those of strengthening the old, the state department of public works decided in favor of the latter, since roadway width is 23½ ft. against a required minimum of 18 ft., vertical clearance is ample and the trusses are good for H-15 loads. Only the floor system is sub-standard, being posted for 6 tons. Revamping, therefore, will consist in replacing the floor—beams, stringers and surface —with new and modern materials that weigh no more but give an H-15 capacity. Plans are complete and the work is scheduled for an early start.

As shown in Fig. 1, the existing trusses are of Baltimore type. With ten panels of 15½ ft. each, the total length between end pins is 155 ft. Between the trusses, which are 26½ ft. on centers, there is a 23½-ft. roadway inside the wheel guards, and there are two 5-ft. sidewalks cantilevered from the floorbeams. The maximum vertical height between center lines of the chords is 30 ft. Since, as stated, the capacity of the trusses is good for H-16 loading (on an allowable stress basis of 16,000 lb. per sq. in.), it is not proposed to make any alterations in the trusses other than to straighten some of the sway bracing struts, which are from 8 to 15 in. out of line.

The existing floor system consists of 3-in. planking laid on 6-in. stringers placed in groups of three, each group being 30 in. on centers. The capacity of these stringers is H-7 loading. Floorbeams consist of 30x¼-in. web and 4x4x⅜-in. flange angles. Sidewalks are bracketed out from these floorbeams, which are sus-

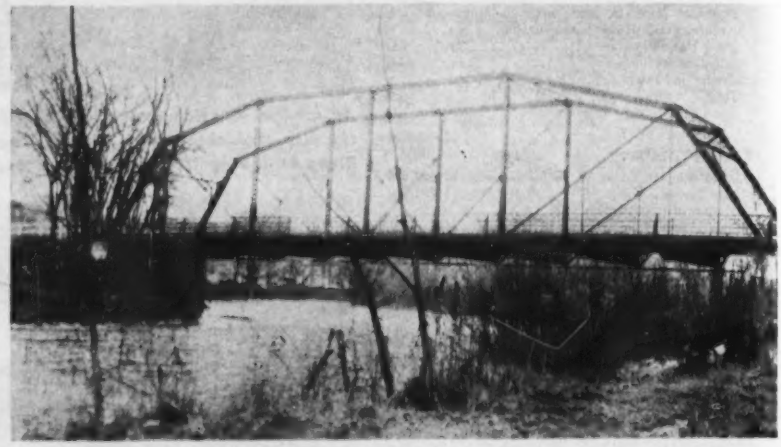


Fig. 1. New floor will increase capacity of this 45-yr.-old bridge from H-7 to H-15. Clearance and truss strength are adequate for modern traffic.

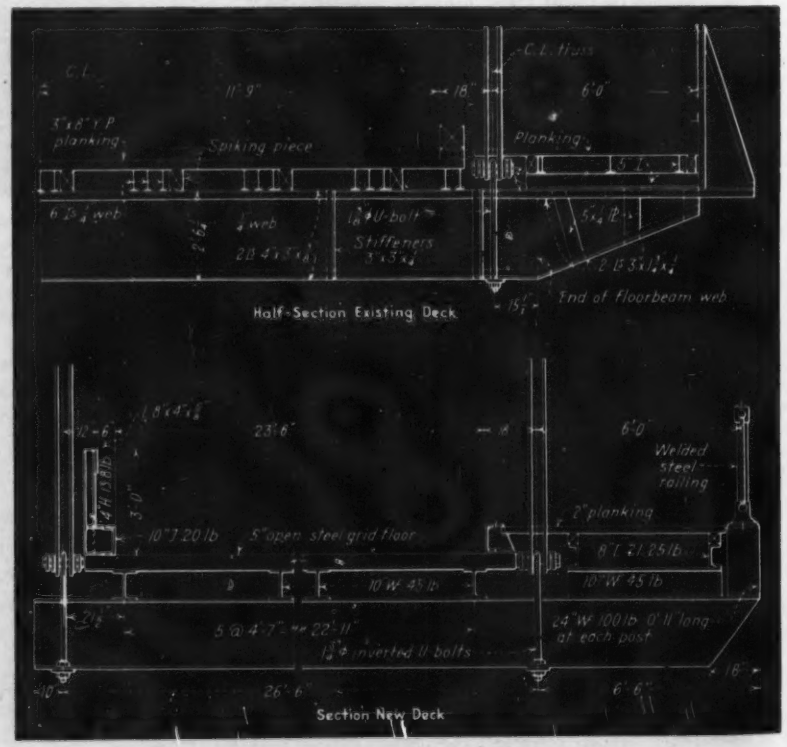


Fig. 2. Comparison of old and new floors on Greenfield bridge. Weighing no more than the old, the new floor will double the bridge's load-carrying capacity.

pended from the lower chord pins with inverted U-bolts. Details of this old floor system as well as of the proposed new system are given in Fig. 2.

In installing the new floor system removal of the nuts on the U-bolts will permit the removal of the floorbeams and with them the planking, stringers and sidewalks. The new floorbeams will be 24-in. 94-lb. wide-flange sections extended on the south side to carry a sidewalk. There will be no sidewalk on the north side. On top of the floorbeams 10-in. 49-lb. wide-flange stringers placed 4 ft. 7 in. on centers will be installed. These will support a 5-in. open grating steel deck. The weight of this proposed floor will be about the same as that of the existing floor, but it will be good for H-15 loading; and its stiffness will be considerably greater.

The estimated cost of these repairs is $20,000, while it would cost several times as much to build a completely new bridge. The work is under the direction of George E. Harkness, bridge engineer of the state department of public works.

Test Road Compares Bases Of Varying Thickness

***Contents in Brief**—A test road at Sacramento, Calif., is being used to determine the comparative thicknesses of different types of stabilized or treated bases (with a relatively light bituminous surface) that will give satisfactory service under light traffic on weak subgrades.*

HIGHWAY BASES of eight types, some stabilized with cement, some with asphalt and some untreated, are being tried out on a test road near Sacramento, Calif., under supervision of the California Division of Highways. The purpose is to make comparative tests of the different low-cost road designs and materials with a view to selecting the most economical base, under light traffic, both with regard to first cost and subsequent maintenance costs. A feature of this project is the placing of the road bases to be tested in strips 100 ft. long varying in thickness from the minimum that could be considered practicable, to a thickness that should withstand all ordinary wear, thus giving an indication of how the failure progresses and at which thickness the several types are adequate to render service under the test loads that are used.

The test road is of oval shape with two 200-ft. tangents whose ends are connected by semicircular arcs. Each of the two tangents, which are 15 ft. wide, contains four 7½x100-ft. test panels, thus putting a different base under each of the two wheel tracks. Subgrade for the entire test section was prepared by excavating a trench in underlying hardpan and placing therein a 6-in. layer of clean, porous sand and screenings with pipes for admitting water. Over the sand is a 12-in. cover of soil with very low bearing value (saturated bearing value 5 per cent or less).

Oval track being used in California to determine the relative merits of various methods of base stabilization.

On this foundation the base materials were placed, increasing the thickness uniformly from a 3-in. base (plus a 2-in. surface) to an 18-in. thickness, also with a 2-in. surface. The point at which failure of maximum thickness occurs is expected to indicate the comparative strength and serviceability of the different types of construction, and direct observation should show how much benefit derives from the various forms of stabilization.

The eight bases comprise:

(1) Crusher-run base (untreated) with a minimum bearing value of 100 percent.
(2) Cemented gravel mixture (untreated) with a 50-percent bearing value.
(3) Same as (2) stabilized with 5-percent emulsified asphalt.
(4) Same as (2) stabilized with 6-percent portland cement.
(5) Sand-clay mixture (untreated) with a 15-percent bearing value.
(6) Same as (5) stabilized with 5-percent emulsified asphalt.
(7) Same as (5) stabilized with 6-percent Portland cement.
(8) Same as (5) stabilized with 5 percent of a special cut-back asphalt.

Over the entire test area a plant-mixed asphaltic surfacing 2 in. thick was laid to protect the surface and to insure uniformity of load application. Subgrade base and bituminous wearing surface were compacted to the same extent as under favorable construction conditions.

Before the test was begun, water was put into the sand layer until water level rose to the underside of the layer of low-bearing-value soil. Thereafter the water inflow was continued at a rate just sufficient to maintain the water at this level until complete saturation of the 12-in. layer of soil had occurred as the result of capillary attraction.

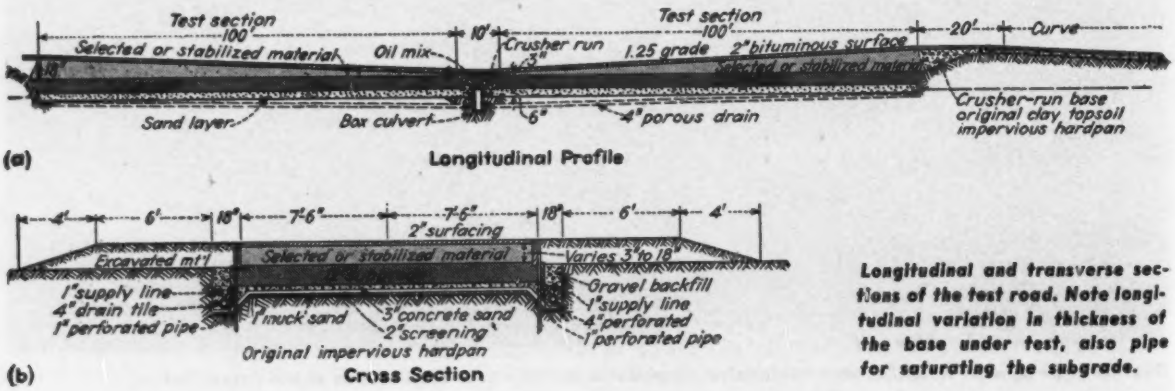
With the subgrade saturated in this way, a loaded truck was started around the track, using first the legal load limit (17,000 lb. on the rear axle). Under this load failures in the thinner sections occurred too rapidly for satisfactory observation and the rear axle loading was reduced to 12,000 lb. The test load is operated around the track at 15 mph.

Each failure of the road surface is repaired as it develops, after noting position and character of the failed area. Thus the surface is maintained constantly in good condition in order that no sound area may be prejudiced by pounding resultant from adjacent broken areas.

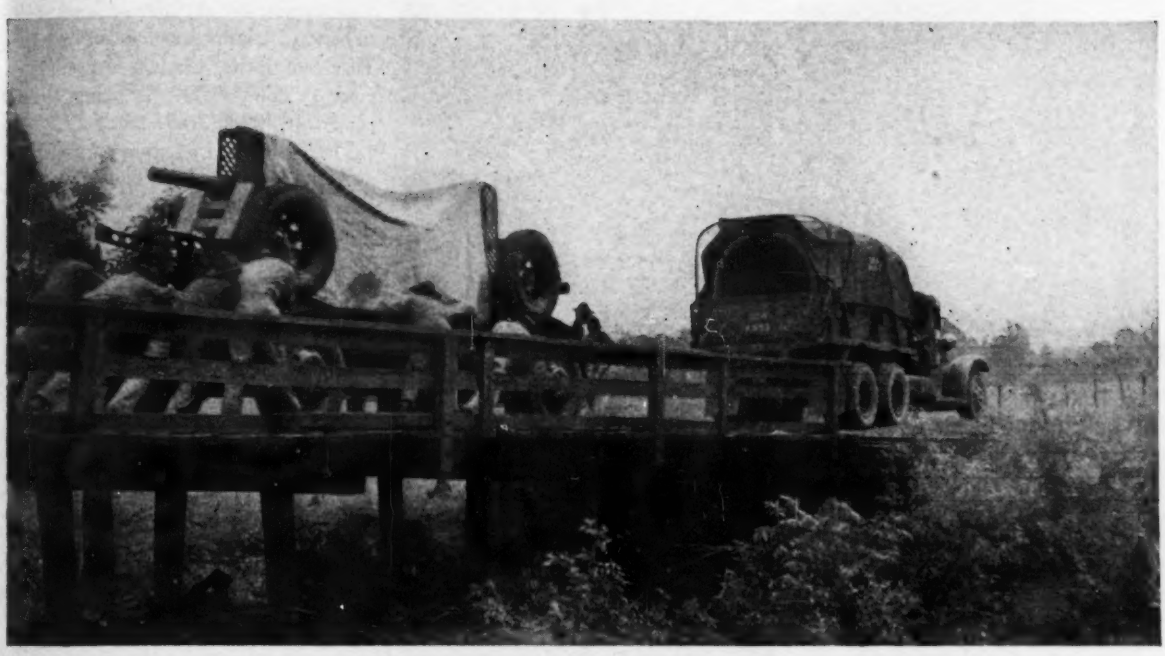
Tests were begun in the fall and were continued for 15,000 passes of the truck before closing down for the winter. During the rainy season it is expected that all bases and subgrades will take up a comparatively high percentage of moisture (the California Division of Highways has found this to be the case even in arid climates like Imperial Valley) and thus in the spring after all materials have had an opportunity to absorb moisture from winter rains as well as by capillarity, the test will be continued to obtain data for final conclusions. Officials of the Division of Highways have stated that until the tests have been completed, results will not be considered conclusive.

Supervision of the tests is under direction of T. E. Stanton, materials and research engineer, Division of Highways, California Department of Public Works.

White lines are used on the test road to guide the truck driver in keeping his wheels spaced uniformly with respect to the center line.



Longitudinal and transverse sections of the test road. Note longitudinal variation in thickness of the base under test, also pipe for saturating the subgrade.



This happened in a mock war; Texas doesn't want it to happen in a real one.

Military Highway Problems in Texas

***Contents in Brief**—Texas, with 6,375 miles out of the 75,000 miles of highways designated by military authorities as of strategic importance, furnishes a striking example of the problems facing the nation in bringing its roads up to military standards. A survey reveals that 87 percent of the designated mileage in Texas is below minimum military requirements. Poor and dangerous alignment, inadequate and narrow surfacing, lack of suitable shoulders, narrow and weak bridges and tight underpasses are some of the faults that will require $80,000,000 to correct in this one state.*

TEXAS, because of its size, its location, and the large number of military camps and bases within its borders, includes by far the largest percentage of the strategic military highway network designated as of vital importance by federal authorities. Yet, except for magnitude, the problems of bringing existing roads in Texas up to military standards are no different from those in most states and can be considered as typical for the whole country. Much of the mileage on the strategic network in Texas is below minimum requirements in respect to width of paving, type of surfacing, shoulders, alignment and bridge strength and clearance. The state, in common with many others, lacks sufficient funds to expand and reconstruct its highway facilities at a sufficient rate to meet normal civilian requirements; prompt rehabilitation of roads to military requirements is financially impossible with available funds.

From Sabine Pass on the Louisiana line to Brownsville at the mouth of the Rio Grande stretch nearly 500 miles of seacoast, and from Brownsville to El Paso are more than 1,000 miles of international boundary. Thus, from a defense standpoint, Texas is an important military state. It has long been the location of many important army posts, and largely because of its favorable climate, it has been selected as the site of numerous new camps and training centers for both the army and navy. At present there are 35 military posts, bases and training centers in the state, including those under construction. Then, too, Texas houses many vital war industries, such as refineries, aircraft plants and shipyards.

Large share of military roads

These conditions call for military roads. Out of the 75,000 miles of strategic highway network designated for the entire country, Texas includes 6,375 miles, or 8.5 percent of the total. The state's share amounts to 27 percent of its state highway system. Included in the 6,375 miles are 4,154 miles designated as part of the first priority military network.

Studies by the highway department show that traffic on the designated military roads now averages 1,642 vehicles per day on the first priority and 1,131 vehicles on the third priority. While the roads in the military network constitute only 27 percent of the state highway system, they carry 55 percent of the normal traffic.

Present roads inadequate

Standards set by the military authorities for the strategic highway network are as follows: Road surface and foundations—all-weather,

Many bridges are inadequate for military use. The one at the left is on Texas Route 118 near the eastern border and the other is on U. S. 90 at Beaumont.

was found on 39 miles, and 419 miles are still unsurfaced earth. Texas highway officials estimate a cost of $80,000,000 to bring these roads up to required standards.

The above is a summary based on overall requirements. Roads for military service should have adequate shoulders where the mechanized units may be temporarily parked. On thousands of miles of Texas highways there are no shoulders, or they are narrow and soft. Bottlenecks exist by the hundreds, such as sharp turns, short culverts, bad intersections, and congested routes through towns and cities. Also, in many places, especially in the eastern lowlands, important roads are subject to flooding.

dustless and designed in accordance with present practices of individual states for repeated application of a 9,000-lb. wheel load. Two-lane pavement width—18-ft. width acceptable, but not desirable; for new construction and reconstruction, 20 ft. for present traffic of less than 600 vehicles per day, 22 ft. for traffic of 600 to 1,800 vehicles, and 24 ft. for traffic over 1,800 vehicles. The state highway department made a survey of all roads in the strategic network to determine their present condition. The findings were not encouraging, as shown by the accompanying illustrations. Because of one fault or another, a total of 5,100 miles, or 87 percent of the designated mileage, fails to meet minimum requirements. Roads under 22-ft. width on the network total 4,478 miles. The flexible base on an additional 163 miles is less than the required 9-in. thickness. "Of doubtful bituminous surface" is the classification given to 181 miles. Unpaved gravel surface

Narrow pavement on fill without adequate shoulders, typical of western Texas, on U. S. 90 near Sanderson.

Narrow streets are a major source of delay to military movements. This is Sulphur Springs, where one of the main highways, U. S. 67, runs through the congested streets.

Weak, narrow and low bridges and underpasses, however, form the worst bottlenecks and obstructions to military traffic. A survey of all bridges on the strategic network reveals that 1,296 structures, or 56 percent of the total, are below desired military requirements. Out of this list the bridge department has selected 136 that should receive first attention, divided as follows: new bridges required on relocation, 8; to be reconstructed, 112; to be widened, 16. Acceptable standards for the strategic network have been designated as follows: loading, H-15; vertical clearance, 12.5 ft.; horizontal clearance, 18 ft. On new construction and reconstruction the requirements are higher. Loading has been increased to H-20 for urban areas, vertical clearance is raised to 14 ft., and horizontal clearance is widened to 24, 26 and 28 ft. for bridges, for under 600, from 600 to 1,800, and over 1,800 vehicles per day, respec-

tively, and to 30 ft. for underpasses. These are minimum standards. Preferable standards are even higher, but the Texas highway department is considering only the minimum in its planning.

Except for the long Corpus Christi Bay causeway, most of the inadequate structures are of relatively short span. According to the bridge engineer, all major bridges are satisfactory. Yet estimates show that it will cost $8,165,200 for rehabilitating the 136 bridges and underpasses scheduled for the first program, divided $518,000 for new construction, $7,417,300 for reconstruction, and $229,900 for widening.

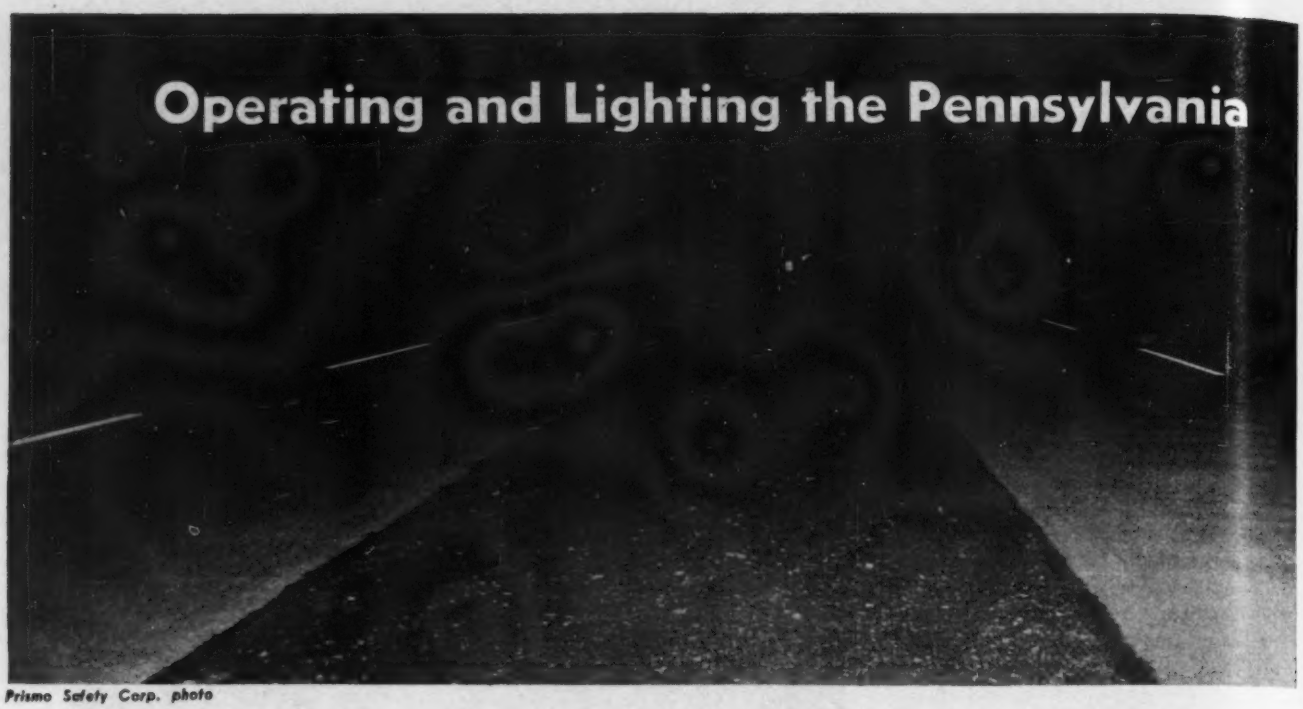
Texas highway officials are keenly aware of the importance of adequate military roads. They saw the army handicapped in its maneuvers in the eastern part of the state last year because of poor highway facilities, and saw the damage done to light surfaces by heavy mechanized units. They realize that the increased traffic developed by the 35 camps and bases must be taken care of and that these military bases must have proper access roads. Then, too, they realize the need of a military road network for the defense of their large state with its long seacoast and international boundary.

The Texas highway commission also keeps in mind the peacetime requirements for its state system. Though the state has invested $400,000,000 in its state routes, 8,860 miles on the system are only partly improved, 5,600 miles are in need of reconstruction, 4,836 miles of farm-to-market roads are needed, and 3,116 miles of additional designations are pending before the commission. Texas has always operated on a pay-as-you-go basis, without issuing bonds or going into debt in any manner for its state highway system. Yet it will require 14 years at the current rate of expenditures of $30,000,000 to bring the entire state mileage up to present-day standards.

In considering both civil and military highway needs, the commission has expressed its willingness to give priority to the military network in this year's program, but discourages spending of state money on purely military access roads to camps. However, the department has made surveys and has prepared plans for access roads to three camps.

Bridge and underpass obstructions to military traffic. A—Short sight distance and narrow underpass, U. S. 80 near Sweetwater. B—Bridge under 18 ft. in width at Belton, U. S. 81. C—Low-water bridge and narrow, weak pavement, near Fredericksburg. D—Sharp curve through underpass at Hillsboro.

Operating and Lighting the Pennsylvania



Prismo Safety Corp. photo

***Contents in Brief**—Lane marking, placing of signs and the lighting of zones on the Pennsylvania Turnpike where caution must be observed has been completed and the highway has been in operation for over three months. This article tells how the lane marking and lighting of the open road has been done, describes the tunnel lighting in detail, and gives a summary of operating experience available since the turnpike opened on Oct. 1, 1940.*

THE PENNSYLVANIA TURNPIKE, extending 161 miles through the Appalachian Mountains between Harrisburg and Pittsburgh, has been open to traffic for over three months. All lane marking and lighting have been completed at intersections and at other points where caution has to be observed, and the operating staff has had time to get adjusted to its work. The three-month period also has given some indications as to types and volume of traffic to be expected. While the Pennsylvania Turnpike Commission is not prepared to make any formal statement as to operating experience because its staff is not yet working under conditions that are considered normal, it has made public sufficient information as to traffic and operating experience to indicate that the revenue from traffic on the turnpike is quite close to expectations though the character of traffic varies from the engineers' predictions for normal fall use.

What was not expected in the operating experience is clear evidence that few automobiles can stand the sustained high speeds that are possible on the turnpike. Mechanical failures have been high and tires have been seriously damaged.

Built to be operated as a toll highway for high-speed passenger and long-haul truck service until such time as its bonds have been paid off, the turnpike consits of four 12-ft. lanes of concrete pavement, two in each direction, separated by a 10-ft. median strip in which shrubs are to be planted to form a separating barrier.

Through the mountain tunnels, of which there are seven having an aggregate length of 6.8 miles, there are but two lanes, 11 ft. wide. Tunnel approaches, however, are laid out so that a second two-lane tunnel can be added when needed. There is no cross-traffic on the turnpike, and no stop signs nor traffic lights. Traffic enters and leaves the turnpike only at the ends and 9 intermediate points where ample provision has been made for merging and separating traffic without confusion. The entire length is tightly fenced to exclude trespassing, especially of animals.

Under this arrangement passenger cars and trucks may travel the full length of the turnpike without delay and with no stops except at the entrances and exits. Experience to date has shown that the two-lane tunnels do not delay passenger vehicles by requiring them to merge with truck traffic because trucks travel at the maximum speed permitted in the tunnels, which is 50 mph. approaching the portals and 35 mph. through the tunnels.

Ingress and egress facilities are located near important towns and connecting roads and are so constructed that they prevent any cross-flow of traffic, yet bring both entering and departing traffic past a single ticket house, thus reducing the personnel and utilities required. A driver entering the turnpike is given a ticket showing the station of entry and this ticket is taken up at the point of exit and the toll collected there on the basis of the distance traveled, $1.50 for a passenger car for the full distance and about 1c. per mile for less than the full route with truck fares ranging up to $10 for the heaviest units.

Roadway marking

The entire roadway is marked to protect the high speed potentials of the turnpike. Warning signs, utilizing reflector buttons, are set two miles or more from interchanges, and the warning of approach to tun-

Above, lane markings stand out at night due to light reflected from glass globules in the paint. Below, mercury vapor lamps get their first tunnel use on turnpike.

nels or other points requiring caution are ample. Allowing slightly more than half the roadway for the outside lane of traffic, a 6-in.-wide stripe separates the two lanes moving in one direction. At interchanges and tunnels, this line is continuous; on the open road it is intermittent stripe and open space in 25-ft. lengths. The paint averaged about 200 ft. per gal, with 6 lb. of minute glass spheres added to the top to give many rounded surfaces which reflect the headlight beams back to the driver, thus showing the lane marking even if fog is encountered.

The line of the road is marked by delineators, six-button reflectors set just at the edge of the shoulder with double-faced delineators in the center of the median strip. These are set $3\frac{1}{2}$ ft. above the roadway on posts made from light metal angles which will bend over easily if struck.

Lighting on the turnpike is confined to the tunnels and their immediate approaches and to interchanges; the appearance of lights being a warning of an unusual road condition which requires caution.

Sodium vapor lamps of 10,000-lumen output which give a soft yellow light were selected for all interchanges, exits, overpasses and approaches to tunnels, and filament or fluorescent lamps giving white light are used at ticket booths and offices. Inside the tunnels high-intensity mercury-vapor lamps (10,000 lumens) were selected for the following reasons: (1) The bluewhite color makes contrasts clearly visible and permits distance to be judged readily; (2) the light source is concentrated, permitting efficient control of the light and its effective distribution by suitable reflecting media; (3) tests have shown that the life of the lamp on continuous burning, such as is required in tunnel lighting, is usually long.

Lighting the tunnels

At tunnel portals which are bellmouthed, permitting infiltration of daylight to supplement tunnel light-

Westinghouse Electric & Mfg. Co. photo

ing, the artificial illumination is stepped up to allow the eye time to adjust itself and overcome the temporary blindness often experienced when passing from sunlight to tunnel light.

There are four major features in which the turnpike tunnel lighting differs from that heretofore employed in similar service:

1. The lighting units are installed in the ceiling slabs, staggered over each of the two lanes in which traffic moves in opposite directions instead of in the upper part of the side walls, as has been customary in the past. They are spaced 37 ft. apart measured along the center line of the roadway.

2. Luminaires are of the so-called "open" type; that is, no glass cover is interposed between the reflector and the tunnel interior. Typical past practice has been to employ a glass diffusing or refracting plate covering the mouth of the reflector.

3. Mercury-vapor lamps are used. Past practice has generally used tungsten filament incandescent lamps, although in one or two notable tunnel installations, sodium-vapor lamps have been used.

4. The optical features of the luminaire are designed for easy and quick removal from their housing, so that cleaning may be performed at the tunnel portal where facilities are provided. The cleaning schedule provides that clean, spare optical parts are immediately substituted for the removed soiled parts, so that service is interrupted for only a few seconds.

The luminaire is mounted in a housing built into the ceiling slab during construction. It consists of a specular stippled reflector with a curvature designed to spread the light up and down the tunnel and with an absolute cutoff at 75 deg.

Each mercury-vapor lamp is controlled by an isolating transformer operated on a constant-current series circuit. The energy for all turnpike lighting is obtained from the local power companies and in the unlikely event of power failure in any tunnel, automatically controlled emergency lights operating from batteries, have been installed which instantaneously provide incandescent light in the tunnel and carry the load for the few minutes required for a gasoline-engine-driven generator to pick up the load. The generator starts automatically when the light source fails.

Visibility throughout the entire length of all tunnels is excellent. The most significant feature of the lighting is that there is no appreciable period for eye adjustment to changes in light intensity either in daylight or darkness. The color and character of mercury lighting and the manner in which it has been applied, plus a high intensity of portal illumination, have greatly reduced the period of temporary blindness often experienced in entering a tunnel.

Ventilation of the tunnels

Ventilation of the tunnels is accomplished by two complete sets of fan equipment at each end of each tunnel except the shortest bore, Ray's Hill, where fans are at one portal only. Fans force air into the tunnel where it enters the roadway through vents in the ceiling. The air is permitted to flow out through the tunnel roadway.

All of the fans are the same size, 9 ft. 4 in. dia., with a double inlet of 6 ft. 4 in. dia. Differences in ventilation requirements are taken care of by varying the speed of the fans, 190,000 cu.ft. per min. at 1-in. total pressure water gage to 311,000 cu.ft. at 4-in. pressure water gage for each fan, designed to provide 175 cu.ft. of air per minute per foot of length of tunnel.

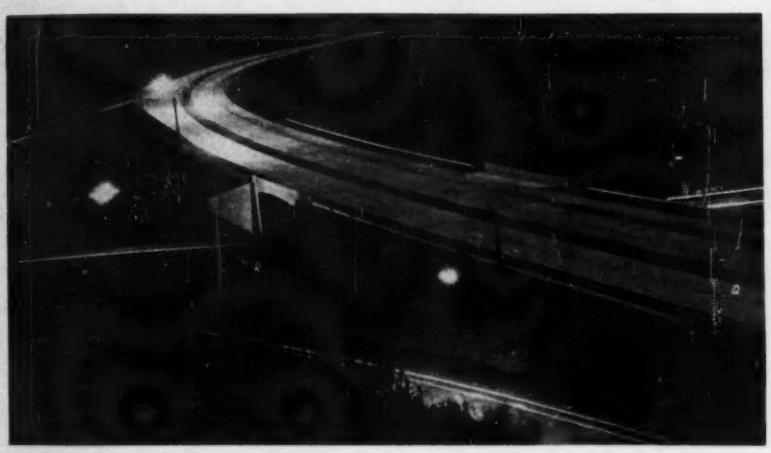
The motors for quarter and half speed are two-speed wound with a single-speed motor for full load. The large motor is expected to operate only a fraction of 1 percent of the time with usual fan operation only at quarter speed. New in ventilating fan drives is the arrangement of two motors connected constantly to the same shaft each driving the other at its designed speed thus eliminating gears or special clutches. Thus the rotor of the full speed motor is turned idle a good deal of the time but at quarter or half speed giving little wear on the moving parts. The small motor will be driven at twice normal speed when the big motor is in use but for such a small period of time that the wear is not appreciable and overall maintenance is expected to be much less than that necessary on the installations where one motor is disengaged. Another innovation is location of the driving motor in an enclosed and heated room separate from the intake area for the fan where outdoor temperatures must prevail.

The control of tunnel lighting, ventilation, and other services is centered at one portal with remote control operation of the facilities housed at the other portal. At Blue Mountain and Kittatinny tunnels, near the eastern terminus, the control of the two tunnels is in one building as only 600 ft. separate the two portals. Carbon monoxide content of the tunnel air is determined from samples automatically taken by vacuum pumps at various points in the tunnel.

Telephones are located at regular intervals through the tunnels connected to the control stations. Communication along the turnpike will be by short-wave radio now being installed. A well equipped emergency truck is stationed at each tunnel. It is capable of wrecker service

Entering the turnpike, the motorist is given a toll ticket which is collected and use charge made at the selected point of exit.

Reflectorized signs give ample warning about the road ahead.



Typical traffic interchange. Sodium-vapor lights give a yellow glow which warns the motorist of unusual traffic conditions.

for the largest trucks and has full first aid and fire fighting equipment with special chemicals for oil and gasoline fires.

Cost and financing

The cost of the Pennsylvania Turnpike is shown in round figures in accompanying table. About $52,380,000 of this amount was paid to contractors for the highway and tunnel construction. The rest of the cost has been divided among engineering, right-of-way, legal and administrative, and cost of financing and interest during the construction and early operation of the roadway.

The money for the work came from a PWA grant, expected to be somewhat less than the $29,250,000 top limit originally set, and from the sale of public revenue bonds to the Reconstruction Finance Corporation. The bonds are 3¾ percent, payable only from income from the turnpike. Proceeds from the bonds and the income from the turnpike can be used only for construction operation, maintenance, or debt service on the bonds issued for the 160.8-mile length of the present road. The Turnpike is to become toll free and is to be operated by the state when the bonds are repaid. Turnpike funds cannot be used for other purposes, even for preliminary surveys of extensions of the route.

The RFC has taken $40,800,000 of turnpike bonds which have been resold through private financial houses. Sales were difficult at first but as the road approached completion there was considerable public demand for the bonds.

The cost of the turnpike is generally stated as $70,050,000; $29,250,000 from PWA, $40,800,000 from RFC. However, the cost shown in the tabulation totals only a little more than $67,000,000. The difference is accounted for by the fact that the RFC purchased the bonds at an average well under 93 percent of face value.

Operations

The turnpike was put in operation on Oct. 1, 1940. A week-day opening without fanfare was selected to avoid "Sunday drivers" until the operating staff had become familiar with its new duties. Despite this precaution, 27,000 vehicles used the road the first two Sundays, many going only short distances. On the first Sunday some delays were experienced at the exit ticket offices but by the second Sunday added ticket booths cared for a larger crowd without difficulty.

Service stations are located along the turnpike at about 30-mile intervals on each side of the roadway (*ENR*, Oct. 31, 1940, p. 580). A large "Midway" station near the center of the Turnpike houses a restaurant with accommodations for 120 and a trucker's dormitory for 38. Smaller stations provide lunchroom services as well as supplying gasoline, fuel oil, and lubricants. All stations are operated by the Standard Oil Co. of Pennsylvania, which obtained a 30-year franchise by competitive bidding against other large companies. The Turnpike Commission will receive 2c. per gal. on gas sold and a stipulated percentage on other commodities. Sales on the turnpike are made at the same price as that at stations off the highway in the same area.

Better than the cars

The road is operated without a posted speed limit except at the tunnels. The Pennsylvania motor police patrol the road to curb reckless driving and handle unusual traffic problems. Excessive speed has been checked more by the experience of operators that cars and tires do not stand up under the high sustained speeds possible on the turnpike than by any other means. Even new cars have difficulty with bearings and mechanical failure at high speeds, and tires are badly worn in a few miles at such speeds if they are not perfectly balanced and aligned.

One tire manufacturer is said to have recommended to the turnpike commission that speeds in excess of 75 mph. should not be permitted. Turnpike authorities state that very

few cars, as normally operated, will successfully stand sustained speeds greater than 75 mph.

Not much difficulty has been experienced with trucks as their motors operate at no higher speeds than are required for lower-gear crossing of the mountains.

Use of the Turnpike

The turnpike authorities do not wish to commit themselves on the traffic indications of the first months' operations as many unusual factors affect the first months' flow of traffic. From published reports, however, several generalities may be drawn:

1. Passenger cars using the road have far exceeded the number expected, computed on a basis of 8.1 percent for October and 6.8 percent for November of the traffic expected during the first year of operation, but the average toll per vehicle has been lower, indicating an appreciable amount of "curiosity" traffic using the road only between adjoining interchanges.
2. Lightweight trucks exceed the anticipated figure substantially.
3. Bus traffic exceeds the anticipated figure slightly.
4. Medium and heavy trucks are below the volume anticipated for the normal fall months but is increasing steadily. Several factors affect this; many carriers operate on routes stipulated in a franchise and time is required to alter them; some truckers are operating a "pilot" truck on the turnpike to determine for themselves its economy before using it for all fleet movements; Pennsylvania limits the load on a semi-trailer to 39,000 lb., adjacent states permitting heavier loads thus offering some inducements for heavy loads to avoid the state; truckers are asking lower toll rates and may not consider it wise to use the road extensively while negotiations are in progress.

STATISTICS

Excavation and borrow	25,540,740 cu. yd.
Tunnel excavation	763,070 cu. yd.
Reinforced concrete paving	4,300,000 sq. yd.
Macadam paving	150,000 sq. yd.
Total concrete used, including paving	1,638,000 cu. yd.
Roadway grading ($139,000 per mile)	$21,000,000
Tunnels ($450 per lin. ft.)	13,500,000
Paving, fencing, etc. ($98,000 per mile)	16,000,000
Traffic facilities and communication	1,500,000
Engineering, surveys, plans, inspection	4,416,000
Right of way ($2,000,000 for old South Penn R.R.)	2,500,000
Legal and administration	1,610,000
Transportation, office, and engineering equipment	520,000
Interest, during construction and reserve for one year	2,630,000

Maintenance crews on the turnpike are somewhat mixed with crews engaged in completing the construction, hence the size of crews and normal cost of maintenance and operation cannot be given with much accuracy at this time. However, the financial house handling the bonds uses a figure of $5,307 as the average daily operation and interest requirement with the income for October and November averaging $6,731. This does not include amortization of the bonds.

The 3¾ percent bonds purchased over the last two years by the RFC at less than 93 are now bringing 109 or better in the market. It must be remembered, however, that the tolls are financing only $40,800,000 of the $70,050,000 total cost of the turnpike.

Turnpike personnel

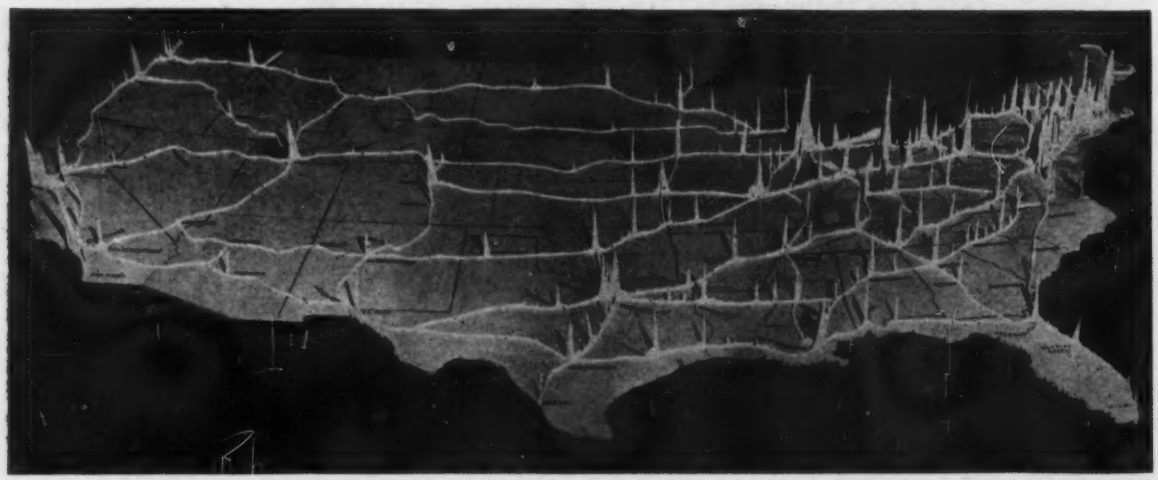
The turnpike was designed and constructed by the Pennsylvania Turnpike Commission of which Walter A. Jones is chairman. During construction Samuel W. Marshall, formerly head of the Pennsylvania department of highways, was chief engineer; Fred S. Poorman, assistant chief engineer; Rodger W. Stone, chief construction engineer; John Paul, assistant construction engineer; Richard M. Merriman, tunnel engineer; R. F. Graef, bridge engineer; Edgar C. Marty, mechanical and electrical engineer; and Charles M. Noble, special highway engineer.

The J. E. Greiner Co. of Baltimore have acted as consultants on the project and Parsons, Klapp, Brinckerhoff & Douglas of New York City as traffic engineers.

The paragraphs in this article describing the tunnel lighting are based on information supplied by L. A. S. Wood, chief lighting engineer, Westinghouse Electric & Manufacturing Co., Cleveland, Ohio.

Traffic Peaks on the Strategic Highway Network

THE CLOSE RELATION between commercial needs for better main highways and military needs is shown clearly in this relief map prepared by the Public Roads Administration. In making the map, traffic density on the 29,300-mile interregional highway system, as outlined in "Toll Roads and Free Roads," was used as the vertical scale. Especially notable are the peaks along the North Atlantic Seaboard.



High-relief traffic map showing the great increase in density on interregional highways that occurs at industrial centers.

New National Airport at Gravelly Point, Washington, D. C. (airview taken during construction) Over 60,000 ft. of 12" to 60" Lock Joint Concrete Pipe used for drainage and sewerage.

Lowry Field, Denver, Colo. Part of more than 78,000 ft. of 6" to 42" Lock Joint Concrete Pipe used at this airport. 18,000 ft. used for sewerage of buildings, quarters, and barracks.

U.S. ARMY AIR CORPS PHOTO

Water supply is a vital part of National Defense. Lock Joint Reinforced Concrete Pressure Pipe is the ideal material for water transmission because of its maximum hydraulic usefulness. View at Norfolk, Va. where 44,000 ft. of 30" pipe is under production to increase water service to Naval Operating Base. Also 24" pipe for a new sewer force main.

Brainard Field, Hartford, Connecticut. Twin lines of 66" Lock Joint Concrete Pipe under Clark Dike. Flood control for the protection of Airports and Industrial Centers is essential to National Defense.

Lock Joint Subaqueous Pipe finds many uses on projects located near large bodies of water—intakes for fresh or salt water supplies for processing or cooling; outfalls for disposal of wastes. View shows production of 101" pipe for Toledo, Ohio, water supply intake.

PIPE LINES FOR DEFENSE INDUSTRIES

Industry is faced with the task of rushing Defense Construction. New plants must be built and old ones extended. Three important factors will have to be coordinated in this work—1. Time of completion. 2. Overall cost. 3. Quality of finished product.

For much of this work, water supply, sewer and drain lines are prime necessities.

If you are faced with the problem of building such pipe lines, consult your nearest Lock Joint representative because:

1. Lock Joint can complete manufacture and delivery of pipe within the shortest possible time.

2. In many cases, Lock Joint can quote a firm contract price for the complete job.

3. Lock Joint has the experience and skilled man-power to assure a completed pipe line of the highest quality.

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Shown on this page are a few of the many ways in which Lock Joint Concrete Pipe is already serving in the National Defense Program. Projects now under way include water supply lines, sewers, culverts, and drains for Industry, Airports, Army and Navy Bases, Power Projects, Municipalities, Railroads and Highways.

Lock Joint Pipe for Sewers, Culverts and Drains can be supplied in sizes from 6" to 120", and for Pressure Pipe Lines from 20" to over 150" for pressures up to 250 pounds per square inch.

You'll find a representative at our main office, or at any one of our permanent plants prepared to help you in every way.

PLANTS ARE LOCATED IN THE FOLLOWING CITIES:

DENVER, COLO.
GREAT BEND, KAN.
KANSAS CITY, MO.
VALLEY PARK, MO.
ROCK ISLAND, ILL.
CHICAGO, ILL.
CLEVELAND, OHIO
KENILWORTH, N. J.
WHITE PLAINS, N. Y.
HARTFORD, CONN.

OCK JOINT *Plain and Reinforced* CONCRETE PIPE

LOCK JOINT PIPE CO. Established 1905 AMPERE, N. J.

CONTRACT UNIT PRICES

What contractor are bidding on different kinds of construction work

HIGHWAY, OHIO

OWNER: Ohio State Highway Department, Columbus, Ohio.

PROJECT: Construction of 3.285 miles of reinforced concrete pavement and brick surface course in Summit County. (Section Akron, C, P, Q, of State Highway 95, Akron). Roadway 48-ft. wide and variable; pavement: two at 22-ft., and two at 24-ft. Project involves grading and structures.

CONDITIONS: Contractor to furnish all materials except those removed from existing structures for re-use, and complete work by November 30, 1941. Rail and highway facilities available for transportation. Wages stipulated are: skilled labor, $1.00 to $1.67½ per hr.; semi-skilled, 65c. to $1.37½; and common labor, 65c. per hr.

BIDS: Two bids were received December 17, 1940, the contract low of $517,547 and $518,429. Estimate, $518,600.

LIST OF BIDDERS:

1. A. J. Baltes, Norwalk, Ohio (contract) $517,547
2. Lombardo Bros. Constr. Co., Cleveland, Ohio 518,429

Item	Quan.	Unit Prices (1)	(2)	(3)*
1. Roadway excavation, undam	66,416 c. y.	$0.45	$0.55	$0.42
2. Seed and protect rdwy. areas	66,074 s. y.	.04	.03	.05
3. Borrow (contractor to furnish)	9,767 c. y.	.45	.25	.42
4. Remove, dispose exist. brick pavmt	17,052 s. y.	.25	.25	.30
5. Remove, dispose exist. conc. pavmt	15,477 s. y.	.25	.30	.30
6. Remove exist. brick wearing crse	13,947 s. y.	.20	.25	.30
7. Remove exist. conc. drive, 6-in	300 s. y.	.25	.25	.30
8. Remove, dispose exist. sidewalk	14,325 s. f.	.04	.01	.02
9. Remove trees and stumps	179 ea.	10.00	10.00	7.00
10. Cut and seal exist. pavmt. edge	829 l. f.	.40	.10	.04
11. Seal exist. pavmt. edge	8,403 l. f.	.03	.05	.02
12. Water (estimated)	348.3 M gal.	3.00	3.00	3.00
13. Remove, store 18-in. corr. met. pipe	18 l. f.	.30	10.00	.45
14. 4 to 12-in. pipe, remove and store	9,811 l. f.	.30	.30	.20
15. 15 to 18-in. pipe; remove, store	4,562 l. f.	.35	.40	.40
16. Remove 12-in. pipe for reuse	120 l. f.	.35	.40	.30
17. Remove 20-in. pipe for reuse	80 l. f.	.35	.50	.50
18. Remove, store 20 to 24-in. pipe	438 l. f.	.40	.60	.65
19. Remove, store 10-in. corr. met. pipe	54 l. f.	.30	.20	.25
20. Remove, store 12-in. corr. met. pipe	105 l. f.	.30	.20	.30
21. Remove, store 15-in. corr. met. pipe	18 l. f.	.30	.30	.35
22. 12-in. corr. met. pipe; driveways	280 l. f.	1.25	1.50	1.50
23. 15-in. vit. sew. pipe; storm sewers	33 l. f.	1.50	1.75	1.55
24. 12-in. vit. sew. pipe; storm sewers	3,808 l. f.	1.30	1.25	1.20
25. 30-in. vit. sew. pipe; storm sewers	72 l. f.	6.00	10.00	6.00
26. 18-in. vit. sew. pipe; storm sewers	42 l. f.	2.00	2.00	2.40
27. 24-in. vit. sew. pipe; storm sewers	66 l. f.	3.15	3.00	3.50
28. 8-in. vit. sew. pipe; rdwy. drainage; porous bkfill	721 l. f.	.75	.60	.65
29. 12-in. pipe; as above	4,810 l. f.	.80	1.00	1.00
30. 15-in. pipe; as above	2,765 l. f.	.95	1.10	1.25
31. 18-in. pipe; as above	970 l. f.	1.50	2.00	1.85
32. 21-in. pipe; as above	512 l. f.	1.95	2.50	2.35
33. 24-in. pipe; as above	1,674 l. f.	2.30	3.50	2.90
34. 30-in. pipe; as above	804 l. f.	4.25	5.00	4.85
35. 4-in. vit. sew. pipe; rdwy. drainage	10 l. f.	.50	.30	.30
36. 12-in. vit. sew. pipe; rdwy. drainage	662 l. f.	.75	1.00	.85
37. 18-in. vit. sew. pipe; rdwy. drainage	180 l. f.	1.30	2.00	1.75
38. 21-in. vit. sew. pipe; rdwy. drainage	246 l. f.	1.70	2.50	2.20
39. 4-in. vit. sew. pipe; underdrains	5,945 l. f.	.70	.60	.60
40. 6-in. vit. sew. pipe; underdrains	13,336 l. f.	.65	1.00	.75
41. 8-in. vit. sew. pipe; underdrains	542 l. f.	.90	1.10	.95
42. 6x4-in. wye pipe spec.; underdrains	83 ea.	1.25	1.00	1.50
43. 6x6-in. wye pipe spec.; underdrains	41 ea.	1.25	2.00	1.80
44. 8x4-in. wye pipe spec.; underdrains	3 ea.	1.50	2.00	2.00
45. 8x8-in. wye pipe spec.; underdrains	12 ea.	1.75	4.00	2.25
46. 12x6-in. wye pipe spec.; underdrains	2 ea.	2.00	3.00	3.00
47. 6x6-in. tee pipe specials; underdrains	1 ea.	1.50	3.00	1.50
48. 8x6-in. reducer pipe spec.; underdrain	6 ea.	1.50	2.00	2.00
49. 12x6-in. wye pipe spec.; rdwy. drainage	1 ea.	2.00	3.00	2.25
50. 12x12-in. wye pipe spec.; rdwy. drainage, incl. porous backfill	3 ea.	3.50	3.00	3.00
51. 15x12-in.; as above	3 ea.	4.00	5.00	4.50
52. 12x18-in.; as above	3 ea.	6.00	6.00	5.25
53. 24x18-in.; as above	2 ea.	7.50	10.00	9.00
54. 30x12-in.; as above	4 ea.	20.00	15.00	21.00
55. 18x18-in. wye pipe spec.; rdwy. drainage	1 ea.	10.00	20.00	10.00
56. 21x12-in. wye pipe spec.; rdwy. drainage	2 ea.	6.50	10.00	8.00
57. 12x4-in. tee pipe spec.; rdwy. drainage	1 ea.	3.50	3.00	2.50
58. 24x12-in. as above	2 ea.	7.50	5.00	9.00
59. Relay 12-in. pipe; rdwy. drainage	120 l. f.	.60	.50	.30
60. Relay 20-in. pipe; rdwy. drainage	80 l. f.	.75	1.00	.60
61. Standard No. 1 manholes	55 ea.	100.00	100.00	105.00
62. Std. No. 3 comb. catch basins (modified A)	138 ea.	165.50	130.00	100.00
63. Std. No. 3 comb. catch basins (modified B)	11 ea.	162.00	120.00	90.00
64. Std. No. 2-3 catch basin	1 ea.	50.00	50.00	40.00
65. Std. No. 7 side-ditch catch basin	44 ea.	38.00	45.00	40.00
66. Manholes adjusted to grade	36 ea.	15.00	10.00	10.00
67. Inlet adjusted to grade	1 ea.	10.00	10.00	10.00
68. Valve boxes adjusted to grade	23 ea.	8.00	10.00	8.00
69. 4-in. concrete sidewalk	35,155.5 s. f.	.22	.20	.22
70. 6-in. concrete sidewalk	1,970 s. f.	.30	.25	.32
71. Conc. steps; 12-in. tread, 6-in. riser	150.9 l. f.	1.75	5.00	1.10
72. Std. str. dex. steel plate guard rail	1,984 l. f.	1.00	1.00	1.10
73. Aggregate for traf. bound side approaches	527 c. y.	2.50	3.00	3.00
74. Remove existing manhole	L. S.	20.00	25.00	10.00
75. Remove 65 exist. inlets	L. S.	325.00	650.00	520.00
76. Aggregate for temp. traffic lanes	2,160 c. y.	2.50	2.00	2.50
77. Calcium chloride	43 ton	35.00	30.00	20.00
78. Riprap for tree protection	80.65 s. y.	4.00	3.00	3.00
79. Aggregate; tree root aeration	138.43 c. y.	2.50	3.00	2.50
80. Commercial fertilizer	17,293 lb.	.03	.02	.035
81. 1-in. insulation crse.; pavmt	1,460 s. y.	.12	.20	.15
82. Coarse aggr., waterbd. mac. base crse	314.2 ton	2.50	2.00	3.50
83. Screenings: waterbound macad. base crse	136.2 ton	2.50	3.00	3.50
84. Asph. conc. leveling course	66.6 c. y.	11.00	11.00	9.60
85. Asph. conc. base course	236.5 c. y.	11.00	11.00	9.70
86. 7-in. rein. Port. cement conc. base crse	41,328 s. y.	1.85	2.00	1.85
87. Asphaltic conc. leveling course (spec.)	440 c. y.	11.00	11.00	9.70
88. Bitum. prime coat	458 gal.	.15	.15	.20
89. Asph. conc. surf. crse., type B	96.1 c. y.	11.00	11.00	9.70
90. Portland cem. conc.; pavement for drives	656.2 s. y.	2.00	2.00	1.55
91. Port. cem. conc. median strip; 4 to 8-ft	3,500.2 s. y.	4.50	3.50	5.00
92. As above; 2-ft. wide	1,613.2 s. y.	5.00	4.00	4.15
93. Rein. Port. c. c. pavmt., 10-8-8-10-in.	41,545.1 s. y.	2.30	2.10	2.30
94. 7-in. rein. Port. cem. pavmt	71.6 s. y.	2.25	2.50	1.95
95. 8-in. rein. Port. cem. conc. pavmt.	381.6 s. y.	2.50	2.50	2.15
96. 3-in. brick surface crse., complete	51,490.9 s. y.	1.95	2.00	2.10
97. 6x18-in. sandstone curb	16,357.2 l. f.	1.35	1.40	1.50
98. Type 4 modified conc. curb and gutter	16,046 l. f.	.90	.10	.70
99. Type 5A modified conc. curb	1,690 l. f.	.15	2.00	.10
100. 9x3½-in. concrete header	388 l. f.	.40	.25	.15
101. 6x18-in. concrete header	110 l. f.	.75	1.00	.60
102. Uncl. excav.; structures	759 c. y.	1.50	1.50	1.50
103. Channel excavation	3,333 c. y.	.75	.80	.65
104. Remove 12-in. pipe for reuse	30 l. f.	.40	.30	.30
105. Remove and store 10-in. pipe	92 l. f.	.40	.40	.25
106. Remove and store 12-in. pipe	22 l. f.	.40	.50	.30
107. Class C conc.; structures	206.5 c. y.	22.00	22.00	20.25
108. Type A waterproofing	8.4 s. y.	.50	1.00	.60
109. Type B waterproofing	30 s. y.	1.60	1.50	1.50
110. Reinforcing steel	20,093 lb.	.05	.06	.06
111. Remove portions exist. structures	13.5 c. y.	10.00	10.00	3.00
112. Dowel holes	132 ea.	.80	1.00	1.00
113. Remove existing structures (per plan)	L. S.	555.00	300.00	240.00
114. 36-in. rein. conc. pipe; rdwy. culv	96 l. f.	5.90	10.00	5.60
115. 12-in. vit. sew. pipe; storm sewer	80 l. f.	.75	1.00	1.05
116. 36x12-in. tee pipe spec.; rdwy. culv	1 ea.	28.00	20.00	32.00
117. Relay 12-in. pipe	30 l. f.	.35	.50	.30
118. Std. No. 2-3 catch basin	1 ea.	40.00	100.00	60.00
119. Type A stone riprap	22 s. y.	3.00	5.00	3.00

*Engineer's estimate.

CULVERT AND SEWER, OHIO

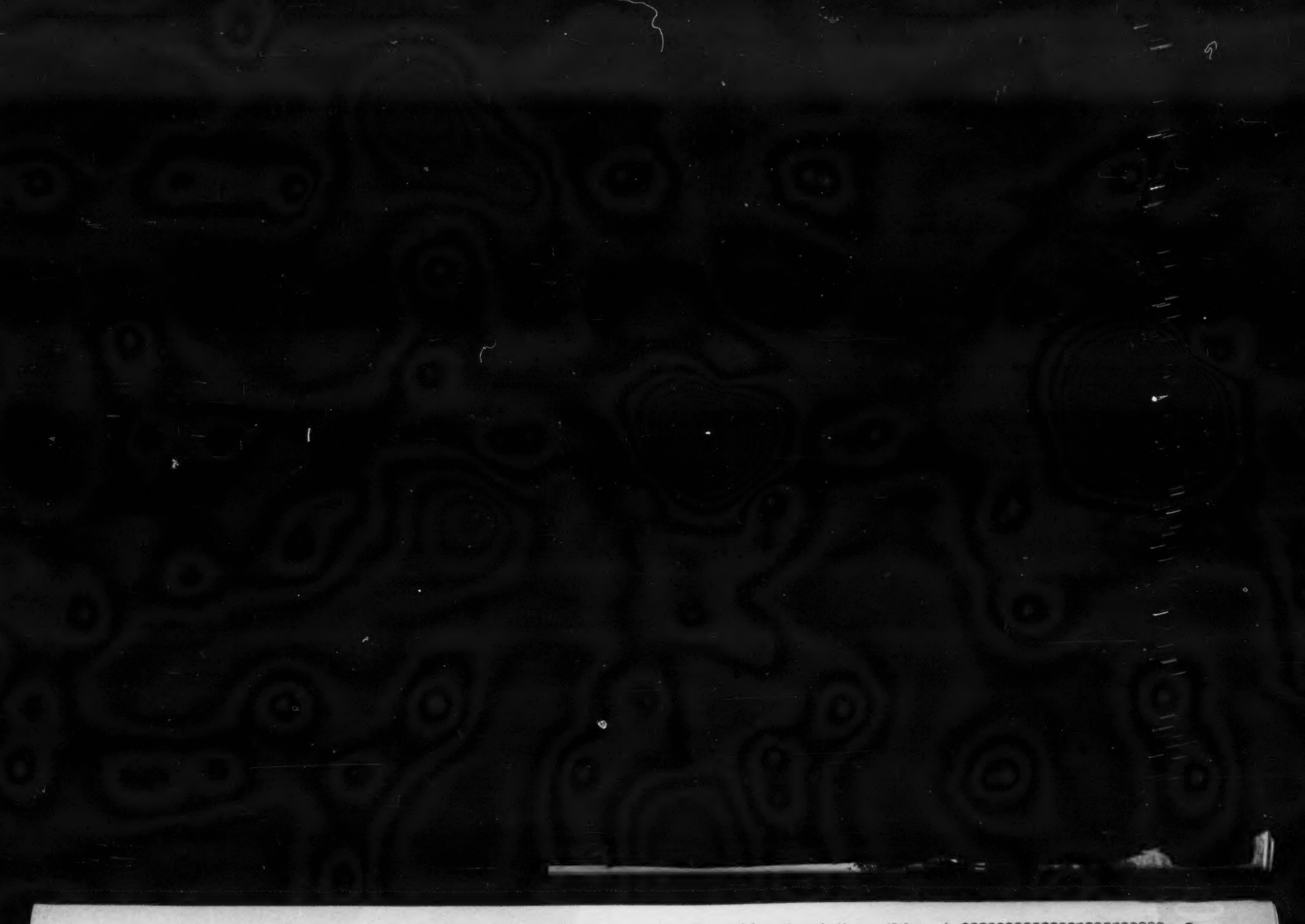
OWNER: City of Cleveland, C. B. Patterson, purch. agt.

PROJECT: Construction of double-barreled box culvert and storm and sanitary sewers in Archmere Avenue SW, from West 35th St. to West 45th St., Cleveland, Ohio. Double sewer length is approximately 1,500-ft; culvert length, 169-ft.

CONDITIONS: Contractor to furnish all materials. Highway transportation facilities available. Wages stipulated are: skilled, $1.50 per hr.; semi-skilled, $1.10; common, 50 to 90c.

BIDS: Four bids were opened December 5, 1940, ranging from the contract low of $24,575 to $27,011.

LIST OF BIDDERS:

1. The Lehman Constr. Co., Cleveland, Ohio (contract) $24,575
2. Domenic Nero, Cleveland, Ohio 24,645
3. Mike Fatol, Cleveland, Ohio 26,031

Item	Quan.	Unit Prices (1)	(2)	(3)
1. Double barrel reinf. conc. culv. (11½x7-ft.)	169 l. f.	$82.15	$90.00	$95.00
2. 15-in. d.a. pipe sewer (storm)	380 l. f.	2.40	2.50	2.50
3. 15-in. d.a. pipe sewer (san.) conc. incased	320 l. f.	4.25	4.25	4.50
4. 27-in. d.a. pipe sewer	70 l. f.	5.00	6.00	5.00
5. 20-in. d.a. pipe sewer	440 l. f.	2.85	2.50	2.00
6. 12-in. d.a. pipe sewer (sanitary)	1,110 l. f.	2.00	1.75	1.50
7. Manholes complete (sanitary)	5 ea.	110.00	110.00	110.00
8. Manholes complete (storm)	4 ea.	85.00	95.00	100.00
9. Catch basin, complete	10 ea.	85.00	95.00	85.00
10. 12-in. straight and curved c.b. pipe	150 l. f.	1.00	2.00	1.00
11. 12-in. slant c.b. pipe	10 ea.	1.50	2.00	1.00
12. 15-in. wye branch	16 ea.	3.00	3.00	3.00
13. 12-in. wye branch	55 ea.	2.50	2.50	2.00
14. 6-in. curb connection	1,072 l. f.	1.00	.65	.75
15. Connection to exist. sewer	1 ea.	5.00	5.00	5.00
16. 6-in. bell and spigot c.i. pipe	168 l. f.	2.00	1.50	1.80
17. 12-in. bell and spigot c.i. pipe	24 l. f.	3.00	3.00	3.00
18. Reinforcing steel	200 lb.	.05	.05	.05
19. Excavation (new channel)	600 c. y.	1.00	.75	.80
20. Monolithic concrete	5 c. y.	10.00	10.00	20.00
21. Additional excavation	10 c. y.	1.00	2.00	1.00
22. Slag backfill	100 ton	2.00	3.00	2.00
23. 6-in. standpipe, complete	150 l. f.	1.00	.65	1.00